THE WOOL-CARDERS' VADE MECUM.

1881.

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BY

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VADE MECUM.

[*Lat.* — "Go with me."] A book or other thing that a person carries with him as a constant companion; a manual. — WEBSTER.

"People should recollect that handicraft itself is capable of being raised to a very high description of Art, and of yielding a very high standard of remuneration. I cannot tell you how anxious I am to impress that upon the minds of young people, and how certain I feel that the lesson is one of great importance to the people of this country. Let them perform their work in the spirit of an artist; let them try to give it excellence, and make a thing that not only will sell, but as good as they can make it; as useful, as well put together, as well proportioned, as pleasing to the eye, as full of beauty, as they can make it; and the more they try to do it, the better they will be able to do it." — Hon. W. E. GLADSTONE'S *Address to the Villagers of Hawarden.*

PREFACE

TO THE THIRD EDITION.

This work made its first appearance, in a modest way, from a town in Western Indiana, in the year 1874.

A *second edition*, somewhat enlarged and improved, was launched in 1876.

There has often been an expressed desire for a more comprehensive work, and in the present issue I have undertaken to satisfy that desire.

This edition has been enlarged to more than double the size of the preceding ones; and the added information, being of a practical character, must enhance the value of the book.

All of Part First, consisting of three chapters, relating to such textile fibres as are likely to

fall into the hands of a so-called woollen carder, is entirely new.

For many of the facts and statistics relating to textile substances I am indebted to the pages of the *Textile Manufacturer*, a monthly periodical published in Manchester, England, and which ought to be read by all parties interested in the development of textile manufacturing.

I am also under obligations to the *Manufacturers' Review and Industrial Record* of New York, a monthly paper now well known in most American mills.

The ordinary routine of the card-room is not entered into, our object being to explain what are considered the principles of the art of carding, a mastery of which enables one to understand and successfully practise that art. Without such a knowledge one can at best but follow in the "rut" worn by others like himself. From a sense of his own weakness, such a one becomes afraid to venture or deviate from the well-worn groove he has adventitiously been placed in. Such an individual is never *master* of his profession, but rather a slave to it.

This book aspires to point out the way. That is all a book can do in any case; and I hope it may prove what I have tried to make it, — a thoroughly practical and reliable Vade Mecum.

W. C. B.

HYDE PARK, Mass., January 1, 1881.

YE OLDEN TIME.

Carding in the Fourteenth Century, from MSS. in British Museum.

CONTENTS.

PART I.

TEXTILE FIBRES.

PART II.

PREPARATION OF THE RAW MATERIALS.

PART III.

THEORETICAL AND PRACTICAL CARDING.

PART IV.

APPENDIX.

INTRODUCTORY REMARKS.

Carding at the present day appears to be pretty generally recognized as the chief agent in the successful manufacture of textile fabrics, and especially of such as are made in whole or in part of wool. No remedy has been discovered for defective carding, and all the after-processes are not only delayed, involving loss of valuable time and costly material, but the result in the manufactured product is unsatisfactory, and its intrinsic value materially lowered, if irregularities have happened during the primary stages of preparation and of carding. Every carder ought to feel the responsibilities of his position, and be ever on the alert to discover and remedy every fault. In order to do so, and become proficient, he must *study* his

profession thoroughly; he must not imagine for a moment that he "knows it all," for such a feeling of egotism stops further investigation, and is only a manifestation of ignorance to all those who know that the subject is an inexhaustible one, and at best one in which we can only approach perfection — never attain it. The more one knows, and the more the illimitable possibilities are opened out before him, the more does he perceive his own ignorance, and the more does he learn. Such a one, whatever his calling, gains new and valuable ideas every day. He also, in the same proportion, becomes of greater value to his employer, and thus is enabled to command a greater recompense for his labor and intelligence.

The carder of to-day possesses immense advantages over those of a few years ago; wonderful improvements have been made in his machines; but we regret to admit that there is no evidence that his skill has improved in equal

ratio. The old-fashioned carders, who were proficient on the old style of carding machines, do not possess the peculiar knowledge demanded nowadays, and a new class have to be produced and educated to the new requirements. Almost within a decade the carding engine, in all its details, has been reorganized; but a far greater revolution has taken place in the materials (conveniently designated as wool) which have now to be carded, and in the working of which the old style of machine cannot be made to answer.

The modern carder must, therefore, adapt himself to the present times, and consider that it is no longer a matter of straightening out the fibre of sheep's wool, but a serious question of the thorough mixing together and perfect carding of materials which but a few years ago were considered as worthless wastage, fit only for manure. Both animal and vegetable fibres, absolutely contrary to each other, differing in

their nature, length, elasticity, strength, and diameter, are now drawn upon to furnish the raw material for woollen cloth. From such mixtures the modern carder must produce a yarn of maximum strength with minimum loss, of great uniformity in respect to both texture and diameter throughout. To accomplish these results with the latest construction of carding implement is no easy task; and to attempt it with the old-fashioned card is folly.

The object of every carder should be to get the utmost out of the "stock" or material in hand it is capable of yielding, whether it be wool or some of its substitutes. In too many cases the only or chief object appears to be one of *quantity;* and there is no doubt, that, upon the whole, we do "get through" more per square inch of carding surface in this country than is done elsewhere; that is to say, more *weight.* But *length* is an important factor, which will have to be more and more considered in pro-

portion as we may in future have to compete with other nations in the economies of woollen manufacturing; and this brings us to the preëminent question of *how* to obtain the greatest attainable length of thread from the material in hand, for it is this knowledge which constitutes a competent carder; and this book is written solely in the interest of that accomplishment, as an assistant, ready of reference to all who desire to know the latest and best means of carrying out the objects we have referred to.

Before passing to a consideration of the various substances now used in the manufacture of yarns for so-called woollen goods, it may be well to impress upon the reader the vital importance of an intimate knowledge of the nature, construction, and properties of such fibres as he may be called upon to use. Once in possession of such information, he has an idea, at the outset, what will best answer as an admixture with another kind, and how to pro-

ceed in their manipulation. Without such information he cannot expect to accomplish satisfactory results, for he goes to work blindfold.

Things which otherwise prove of the most perplexing character are at once explained by an examination of the peculiarities connected with his materials, for these form the basis of the art of carding. It is painful to notice what indifference carders generally manifest on all matters relating to this subject.

Probably no class of artisans know so little of the nature, composition, or properties of the materials they work as carders do; and, considering the extremely delicate nature of these materials, it is surprising that such is the fact.

PART I.

TEXTILE FIBRES

TEXTILE FIBRES.

ANIMAL AND VEGETABLE.

Textile fibres may be arranged into two great classes or divisions; namely, animal and vegetable. Among the former there are the wool of sheep, the hair of goats, camels, etc., and silk. Among the latter there are cotton, flax, jute, etc.

Animal fibres, unlike those of vegetable origin, do not burn in a continuous manner, but undergo a kind of fusion, giving off an odor similar to burnt horn; at the same time a carbonized ball is formed on the end of the burned fibres. The composition of animal fibres is quite uniform, and somewhat resembles gelatine and other albuminous substances. Chevreul has estimated that wool contains 1.78 per cent. of sulphur.

Animal fibres are very susceptible to the action of fixed alkalies, especially when they are

caustic; but the degree of concentration of these agents and their temperature have a great influence upon results.

Animal fibres cannot be brought into contact with chlorine without being affected, but they resist weak acids best of all. When animal fibres are plunged into the colorless solution obtained by boiling fuchsine with an alkali, and are then washed, they will be dyed red; well-cleaned vegetable fibres have not this property. It is by taking advantage of these properties that animal and vegetable fibres are separated for purposes of re-manufacture from cloth otherwise worthless, the process being commonly known as "extracting." Sometimes it is the vegetable that is sought for utilization, but oftener the more valuable animal substance; but in either case the other compound is destroyed, the vegetable by acids or acid gases, and the animal with chlorine, etc.

CHAPTER I.

ANIMAL FIBRES.

SHEEP'S WOOL.

Several animals besides the common sheep produce what is known as wool; for instance, there is the Cashmere goat, known also as the Thibet goat, which has an exceedingly fine wool growing amongst its hair, and which has been used for ages by the weavers of Cashmere in the manufacture of their exquisite shawls. There is also the wool of the Alpaca, which it is said the Peruvian Indians have used for generations as a raw material for their ponchas, blankets, etc.; but it is to Sir Titus Salt that the world is indebted for its utilization, and the application of machinery in its manufacture, which has resulted in the creation of an entirely new industry, that now requires over 2,000,000 lbs. per annum of a fibre which fifty years ago was unknown to commerce. These various textiles will receive attention under

their proper designation farther on; and what concerns us now is, to consider the nature of *sheep's* wool. It will not be necessary to enter into detail concerning all the different sorts of such wool, but to review that class generally comprehended in the term "clothing wool," "fine" or "short" wool.

The basis of all that is valuable in such wools is the merino sheep, a fact that is attested by the entire history of the clothing wool manufacture. Long before the peculiar structure of this wool was revealed by the microscope, experience had led manufacturers to give it preference; and so long as it was supposed that it could not be grown anywhere but in Spain, the manufacturers of other nations cheerfully paid tribute to that country. These fine sheep flourished in Spain before the Christian era; and yet no other country competed before 1765, when the Elector of Saxony introduced them into his dominions, where they actually improved upon their Spanish progenitors, and Saxony succeeded in producing finer wool than Spain, until beaten more recently by Australia; whereupon Spain

sank to a third rank, and the sheep became acclimated in France, the United States, and other countries, until it is now universally sought after as being the best adapted for clothing purposes of any other wool.

In no portion of the world have so much science and intelligence been directed to the merino-sheep industry as in the German States. What is known here as Silesian or Saxony wool is in Germany called Electoral, after the Elector of Saxony, or Escurial, both names being used indifferently, and does not appear to have been the inheritance from any special Spanish cabañas, but a production of art. The fibres of these wools, according to Mall, measures from 1.4 to 1.8 of a centime of a millimeter in diameter; a centime of a millimeter being equal to $\frac{1}{2540}$ of an inch. Dr. George May, in a table of measurements of 55 different kinds of wool, gives the finest, that of a Silesian super-elector, the very highest electoral wool, as averaging 0.13 millimeters, equal to 1,954 hairs to an inch.

The length of these wools rarely surpasses

4 centimeters, and the weight of the average fleece is scarcely over $1\frac{1}{2}$ lbs. They are used at present only for the fabrication of the most precious of woollen goods, imitation Cashmere shawls, extra fine broadcloths, etc. The thick felts now made for the hammers of piano keys are made solely of this wool, imported from Silesia.

Examined under a microscope this wool presents the appearance of being serrated and imbricated; in other words, its fibres are notched like a saw, the teeth being bent over one another like tiles, overlapping at the edges. In a single fibre of merino wool one inch in length there are said to be 2,400 of these serrations; in one of Saxony, 2,700; in South Down, 2,080; in Leicester, only 1,860.

In the production of woollen cloth, that wool is the most valuable which possesses the greatest number of these serrations, because it is by means of these that the felting process, which is the essence of such cloth, is accomplished.

It is on account of the vast number of these serrations, and also the fact that each fibre of

wool is a hollow tube or stem, so covered with this downy coat, overlapping and encircling its every part, that wool is the best absorbent of color of any textile fibre, and therefore the easiest to dye. It is to preserve these delicate hooks that wool is oiled before undergoing the carding process, and the firmness of the cloth depends in a great measure on how perfectly this lubrication is accomplished.

In practice we learn to judge wool by its softness, whiteness, curl, elasticity, density, uniformity, etc.; but the tact or ability to judge of minute differences is acquired only by the repeated trials one is called upon to make in the daily pursuit of his calling. It seems superfluous to add that a material of such delicate structure should be handled with consummate care.

Having pointed out the peculiarities connected with short or clothing wools, we will now hastily examine so-called long or combing wools. Speaking generally, we may say that long wool is coarser than short wool; but all long wool is not necessarily coarse, nor all short

wool fine. The process of combing is adopted either alone or in connection with carding for long wools, and the product arising from the first named process is called worsted, as distinguished from woollen, which is the result of carding short wool; and while for the latter it is important that the fibre should possess the greatest number of serrations to fulfil the milling or fulling operation, this is altogether unnecessary when the wool is to be used in the manufacture of worsteds, for in them this fulling process is either avoided or else carried out to a very limited extent. Instead of seeking to attain the utmost matting and interlacing of the fibres, the object is just the opposite, that is to say, the fibres are required to be drawn and spread out longitudinally and separately along the body of the thread. This object is most perfectly attained by the combing machine, which, in all its forms, seeks to disjoint and detach each one of the separate locks or ringlets of fibre, and arrange them in perfect parallelism. Short fibres are always found intermingled with long wool, and do not, as before explained,

answer for worsted; therefore they are removed by the action of the combing machine, and in that state we call them "noils;" they are then used along with short wools in the manufacture of such goods as do not require a great deal of felting, such as flannels, etc. A considerable quantity of the longest clothing wool is now carded, and then combed; the first operation being merely a preliminary one, in order that the combing machine may produce a larger proportion of long fibre than would otherwise be possible; and it is this long fibre, however derived, which is called "top" in the worsted manufacture. For strictly combing purposes the best wools are such as present a wavy outline and lustrous appearance.

In selecting short or clothing wools the first point to consider is, whether the cloth to be made therefrom requires much felting; in that case, as for broadcloths, a wool of soft, sound, fine texture, showing signs of good felting qualities, and containing grease uniformly distributed throughout the fleece, is the kind most desirable. For cassimeres, or any goods not

requiring much "cover," felting qualities are secondary to good, sound, fine, elastic fibre. As a general rule the felting properties decrease as the wool increases in length, for the more ends there are the more interlocking or felting will take place, and the greatest attainable number of ends is found in the finest and shortest wool.

WOOL STATISTICS.

In the reign of Queen Elizabeth England was estimated to produce 30,000,000 lbs. of wool annually. There was but little imported, and the woollen manufacture employed 700,000 persons. In the middle of the 18th century the production had risen to 80,000,000 lbs., employing in its manufacture 1,500,000 persons. In 1800 the total wool production of the United Kingdom was 96,000,000 lbs., and 9,000,000 lbs. additional were imported. The period between 1830 and the present shows an enormous advance in wool production throughout the world, which has multiplied itself five times during that period. The following table exhibits the comparative growth of the industry: —

	1830.	1880.
Europe . .	280,000,000 lbs.	740,000,000 lbs.
Australia . .	6,000,000 "	370,000,000 "
La Plata . .	22,000,000 "	240,000,000 "
United States,	10,000,000 "	230,000,000 "
South Africa,	2,000,000 "	48,000,000 "
	320,000,000	1,628,000,000

The rapid increase of production in Australia is evidenced when we examine the returns for 1878 and 1879, for we find over 5,000,000 lbs. increase in the short space of one year. About two-thirds of the Australian production is classed as combing wool.

Of the United States production about 90 per cent. is classed as clothing and 10 per cent. combing wool. Of the latter kind there are imported about 20,000,000 lbs., and of imported wools of all kinds there are consumed about 50,000,000 lbs.

The imports and exports of wool in Great Britain may be summarized as follows for the years given : —

Imports.

1800	9,000,000 lbs.
1860	147,000,000 "
1880	509,054,346 "

360,000,000 of which were from the colonies of Great Britain.

Exports.

1860	54,400,000 lbs.
1880	280,000,000 "

There were exported of yarn 27,000,000 lbs. in 1880, and imported 15,000,000 lbs.

There are annually consumed of mungo and shoddy in England about 100,000,000 lbs.

90 per cent. of English clip is classed as combing wool.

Of the wool production of Europe, —

Russia furnishes	296,000,000 lbs.
Great Britain	153,233,300 "
France	75,000,000 "
Germany	60,000,000 "
Austria	50,000,000 "
Spain	57,000,000 "

Italy	18,000,000 lbs.
Other countries	31,000,000 "
	740,000,000 "

The wool production of France, Germany, and Austria has fallen off one-half in twenty years.

To each 100 of the population, —

England has	133 head of sheep.	
France	97 "	"
German States	93 "	"
Russia	81 "	"
Austria	47 "	"
Italy	38 "	"
United States	89 "	"

The common sheep of Russia yield a coarse order of wool, largely used in the manufacture of carpets. The sheep are very prolific, having sometimes four lambs per year. Shearing takes place three times per year, and the fleeces average $3\frac{1}{2}$ lbs. of wool. These sheep are found in the whole of the central and the most of the northern districts of Russia. The Russian clip is said to be worth about $82,449,000.

There is a flock of 230,000 head, pure blood Spanish, owned by Mr. Falz Feru, of the Government of Tauride, in the Crimea. The flock occupy a track of 340,000 acres of land.

One of the largest as well as finest flocks in Europe is owned by Count Alois Karolyr, of Stamphen, Hungary, and numbers 80,000 head; the average weight of washed fleece being $2\frac{3}{4}$ per head of beautiful superfine clothing wool, the staple averaging $1\frac{1}{2}$ inches in length. It is mostly sold to French manufacturers at 74 to 85 cents per lb.

The quantity consumed in the various countries, with the number of spindles and hands employed, has been carefully computed as follows, the consumption including both washed and unwashed wool: —

	No. of workpeople.	No. of spindles.	Lbs. consumed.
Great Britain . .	280,000	5,449,495	435,131,389
France	170,000	2,500,000	350,000,000
United States . .	120,000	2,300,000	280,000,000
Germany . . .	120,000	2,365,114	200,000,000
All other countries,	223,000	1,682,886	365,000,000
Totals .	913,000	14,297,495	1,630,131,389

About 24,000,000 lbs. of combing wool are yearly manufactured in the United States. The worsted business is, however, in process of rapid development, and considerable attention is being given to the growth of suitable wool for combing purposes. English and Australian wool for that purpose is almost wholly used at present, all of which, according to the act of Congress, of March 2d, 1867, must pay a duty of 10 to 12 cents per lb., and 10 to 11 per cent. ad valorem. This wool when ready for manufacture costs the American over 80 per cent. more than the British manufacturer.

About 22,000,000 pounds of shoddy are annually manufactured in the United States.

The number of sheep in the world stands about as follows: —

Australia	60,767,500
Russia	57,387,000
Argentine Republic (La Plata),	56,500,000
United States	40,000,000
Great Britain	32,174,969
France	25,000,000

Germany	20,000,000
South Africa	11,500,000
Other countries . . .	22,700,000
Total	326,028,469

Among large flocks of sheep may be mentioned those in Australia belonging to Price and Browne, of Wilpend Station, 300 miles north of Adelaide, who shear 62,600 head. William Krozier, 280 miles N.E. of Adelaide, shears 60,000 head each season. The flock of John Howard Angas is, however, perhaps, the largest in Australia. It is at Collingrove Station, 50 miles from Adelaide, and numbers over 100,000 head.

A flock of sheep on the Rio Grande, New Mexico, numbers 100,000 head, and there are other single flocks of 80,000. The numbers in such herds are computed by the black sheep, which are nearly always found in a ratio of one to every one hundred of the flock.

CASHMERE WOOL.

The Cashmere or Thibet goat is not a separate species, but merely a variety of the ordinary goat. It is generally black or dark brown, and covered with long, coarse, felted tufts of hair. Under this hair is found fine brownish or gray down, which is easily pulled out, and after being sorted and combed is sold for the production of the renowned Cashmere shawls. White goats are seldom found.

The best breeds are kept on the Himalaya mountains, but the largest quantity comes from Thibet, Cashgar, and many are found in Persia. The quality of the wool differs according to locality, and as a general rule the down is found to be the finest, the higher the ground on which the animals feed. A chief condition for the formation of this valued product is the circumstance that the animals are always kept in the open air; they may occasionally be brought under some kind of shelter, but never under a roof. Every attempt to acclimate the animal in Europe has resulted in failure. The first

importation into the United States, consisting of eight animals from Asia Minor, was made in 1849, by Dr. T. P. Davies. Several thousand are kept on an island in California, and several thousand scattered through Oregon. The acclimation, so difficult in Europe, owing mostly to damp atmosphere, has not been found difficult in the dry climate of this country.

There are many Cashmere goats in Nevada, the climate being very acceptable to them. The land abounds everywhere with a wild grass or sage brush, so bitter in summer that it is unpalatable; but once touched by frost becomes sweet, and seems to be excellent food for the goats. It is known as the wild artemisia. There is one flock of goats near Carson, numbering 3,000 head, which are said to have exceptionally fine and silky fleeces.

MOHAIR.

The Angora goat exists in greatest perfection in Asia Minor and Central Asia. Its fleece is mostly white, and of the same length and quality throughout; they are clipped in May, and

yield $1\frac{1}{2}$ to $2\frac{3}{4}$ pounds of hair, that of the female being the heavier. The finest hair comes from the first clip in the second year of the kid; the second quality from the she-goat, the third from the wether, and the coarsest from the entire male. Van. Mohair is coarser than the Angora sorts, and contains an average of 70 per cent. white, and 30 per cent. red and black.

Pelotons contain 80 per cent. black and red, and 20 per cent. white, all of inferior quality.

This fibre is mostly used in the manufacture of plush, and in imitation of furs and skins of animals, being more suitable for such purposes than other textile fibres, from the fact that the pile or nap can be made to stand erect up to $\frac{3}{4}$ of an inch deep. It is colored (a difficult operation) to imitate the seal, beaver, otter, etc., and sometimes it is difficult to distinguish the imitation from the real. The fibre is more lustrous and brilliant than other wools.

It has the aspect, feel, and lustre of silk without its suppleness. It differs materially from wool, in the want of the felting quality; so that stuffs made of it have the fibres distinctly sep-

arated, and are always brilliant. On account of the stiffness of the fibre it is rarely woven alone; that is, when it is used for the filling the warp is usually of cotton, silk, or wool, or the reverse. It has great durability and brilliancy, which peculiarly fit it for its chief use, — the manufacture of Utrecht velvet or plush; largely used also for forming the pile of imitation seal-skins, many beautiful specimens of this fabric being made by manufacturers in Huddersfield, England. Mohair only began to figure in the exports from the Cape of Good Hope in 1862, the quantity then reported being 1,036 lbs. It now amounts to about 1,500,000 lbs., worth $250,000.

CAMELS' HAIR.

So far as the writer is aware it is only recently that camels' hair has become utilized as a textile material; nor does it appear to be used as yet to any particular extent in this country, except as a mixture with various low stock for backing in beavers, and other similar fabrics.

The fibre is mostly of a light-brown color, and consists of several grades, from a long, rather coarse hair, to a downy undercoat, quite fine and silky, which lies close to the hide. This downy substance is quite short, and exceedingly light and "fluffy," being more like wool or fur than hair. When the shearing takes place the hair and the downy wool being cut at the same time, and baled for shipment in that condition, the two get pretty thoroughly blended together. It seems to be impracticable to sort the fine from the coarse and long except by the combing process. The lowest grades are used in the manufacture of carpets, etc. It formerly came mostly from Western Asia, Persia, and Arabia, through Russia and the Baltic ports, to Liverpool and London. It now comes to this country from China direct, and there is quite a large amount of it used for one purpose or another.

SILK.

The silk fibre shows no more structure under the microscope than can be seen in a length of

gold or silver thread. All that is discernible is a longitudinal depression, or canal, the whole length of the fibre, which may be 300 to 400 yards long. Sometimes this depression becomes an actual opening or separation, dividing the fibre in two. This arises from the fact that the fluid silk, although ejected by the worm from a single orifice, is supplied from two organs, which meet, but sometimes do not unite perfectly together. It is composed of a series of molecules of animal jelly, rendered in a measure porous, by shrinkage during dessication. The pores being on the surface merely, render silk one of the hardest fibres to dye, absorbing but little color.

The fibre varies in size throughout its length, from $\frac{1}{4}$ to $\frac{1}{3}$ of its dimensions, from the outside to the inside of the cocoon, the reason being that the cocoon is commenced from the outside, and as the reservoir of the animal becomes less, the size diminishes as the animal becomes enclosed, and obtains no further nourishment. The section of the fibre is triangular, and no roughness is perceptible on the surface. It is

the longest and strongest fibre known, and the most elastic, as it can be elongated from 20 to 22 per cent. Persoz estimates the tenacity of silk at about $\frac{1}{5}$ of that of iron. Like most textile fibres, it gains in elasticity from dampness, but decreases in tenacity. It is the worst known conductor of electricity and heat, but is itself easily electrified, and once so, remains in that state for a long time. It is easily charged with static electricity induced by friction, and this gives great trouble in carding and spinning silk waste.

Silk is a very hydroscopic substance; in its normal state it contains a certain degree of moisture, which is more or less considerably augmented according to the state of the atmosphere; it therefore offers great latitude to the seller to take advantage of the buyer, especially when it costs $2.50 to $10.00 per lb. The buyer's resource, however, is to have a sample "conditioned," and use the shrinkage as a basis for his calculations.

Each cocoon yields on an average 300 yards of silk; 250 average-sized cocoons weigh about

a pound, and 11 or 12 pounds of cocoons give 1 pound of reeled silk, and the original filament spun by silkworms needed to make this quantity would be nearly 500 miles in length. About 2,304 silkworms die to every pound of silk.

According to Prof. Riley, of St. Louis, the length of the cocoon of a mulberry silkworm is generally 1,000 yards, and a mile of it weighs $15\frac{1}{2}$ grains.

WASTE SILK.

The best silk, wound direct from the cocoon, is called "thrown" silk; but for every pound of this there is left from 12 to 14 pounds, and this is called "waste" silk. It probably got the name of "waste" silk before Samuel Lister, of Bradford, Eng., took hold of it, some 22 years ago. A merchant of London, at that time, called his attention to it as a nuisance, and Lister bought all he had for two cents per pound. After that, for many years Mr. Lister persevered in the attempt to construct machinery for its manufacture, and in 1864 he had

already sunk over £240,000, or about $1,200,-000, in the enterprise, without the slightest return for the investment. But his indomitable perseverance finally triumphed, and the manufacture began of a substance considered worthless for over 4,000 years. The machinery soon turned out not only spun silk of fine texture, but also velvets woven on the power-loom, and the money spent, in what others deemed fruitless imaginings, began to pour in as a reward for his untiring efforts. Colossal works were established at Manningham, costing $2,500,000, and thus began a new industry.

We need not here, however, consider waste silk further than to give the intelligent carder a brief account of its nature and source, from which he may judge of its adaptability as an admixture with other fibres.

There are many different varieties of waste silk, but they may to a certain extent be classed as follows: —

First. Defective cocoons. These arise in different ways, as follows: Where the moth has pierced the cocoon and destroyed the con-

tinuity of the fibre; cocoons in which there are two or more worms, and which cannot therefore be unwound.

Second. Waste from perfect cocoons, consisting of silk unravelled from the cocoons before the end is found; the ends of cocoons which cannot be unwound in the usual way, and the waste in winding. As it is evident that neither of these classes can be utilized except by carding and spinning, as for wool, etc., it becomes necessary to treat the substance much on the same principle. The waste cocoons, etc., are first steeped for several days at a certain temperature until the gum is softened, then they are stamped and washed with hot water and soap, then dried and passed through a sort of picker. After this the process is quite similar to that used in the worsted manufacture. Silk noils, often used in carding wool for Knickerbocker goods, comes from the combing machine as a residue of the process, the same as in wool-combing. What stands for "top" in the latter manufacture is called "first drafts" in silk combing. The shortest fibres are of use for

carding purposes, and will be further mentioned under the head of Blending.

SILK STATISTICS.

The silk production of the world in 1875 was estimated at 58,614,000 pounds, worth $300,000,000.

The countries from which the product is drawn may be given as follows, with the production: —

			Value.
China and Japan	28,200,000 lbs.	at $4 per lb.	$112,780,000
Italy	10,000,000 "	" $8 " "	80,000,000
France . . .	5,207,800 "	" $8 " "	41,600,000
India	8,800,000 "	" $3 " "	26,400,000
Cochin China, Persia, Turkey, etc.	5,340,000 "	" $6 " "	30,490,000
Switzerland, Spain, etc. .	1,000,000 "	" $8 " "	8,000,000
	58,547,800		$299,270,000

The annual import of raw silk into France is valued at $80,800,000
England 20,800,000
United States 11,000,000

Silk Manufacture in the United States.

The imports of manufactured silk goods into the United States amounted, in 1880, to the sum of $32,188,690.

The seat of the silk manufacture in America is at Paterson, New Jersey. About 11,250 people are employed in 39 establishments for the manufacture or dyeing of silk.

The first silk mill in Paterson was started by John Ryle, a Macclesfield weaver, who sailed to America in 1839. He managed the mill for three years, then became a partner, and three years afterwards became sole owner by purchase. For twelve years he had no competitor, and for some time after that there was but one other besides himself in the trade.

Philadelphia employs some 6,500 persons in some 50 concerns, who turn out a product valued at $6,500,000, consuming annually 200-000 pounds of raw silk, worth an average of $4.50 to $5.00 per lb. The cost of manufacture enhances the value fully five times more than the cost of the raw silk.

The Silk Manufacture of Great Britain.

No. of factories	818
" spinning spindles . . .	1,115,000
" power-looms	10,002
" people employed . . .	60,000

The importation into England of raw and thrown silk and silk waste amounts to 7,976,547 pounds, valued at $22,807,705. Add to this the import of manufactured silk, valued at $60,091,660, and the total value of $82,899,365 remains. The export of manufactured goods is valued at $21,087,980, consisting chiefly of broad piece goods and ribbons.

In Italy there are 3,829 concerns engaged in the silk manufacture, running 665 power-looms, 7,394 hand-looms, steam-engines of 10,902 horse-power, and 185,722 work-people.

The Silk Manufacture in France furnishes employment to 69,768 people. There are altogether 500 reeling establishments, and 15 where the manufacture of waste silk is prosecuted, besides 7 engaged in other processes.

The value of French silk manufactures is said to be $112,500,000. There are reeled of

French cocoons,	2,400,000	kilograms.
Foreign "	1,800,000	"

CHAPTER II.

VEGETABLE FIBRES.

COTTON.

The staple of cotton is much finer than that of wool, and consists of hollow-like sacs, tubes, or small vesicles, the openings of which, although not visible under the microscope, are filled with a vegetal marrow, and furnished with innumerable lateral apertures, which only admit of dyes in a greatly attenuated form. Cotton is, therefore, more difficult to dye than either wool or silk. There are three kinds of cotton mostly used in this country: 1st. Nankin, of a dirty yellow color, and consequently low-priced. 2d. Upland, green seed, or bowed, — the latter term being derived from the mode of preparation. It is called also short staple; it is grown inland or upland from the ocean, hence its name. 3d. Sea Island, or long staple, having black seeds and long, white, glossy fibre. It is so called because it is grown on the

low sandy islands off the coast of Savannah and Charleston, where it is constantly sprinkled with salt spray. When removed from this salutary influence it deteriorates in quality. It is the kind mostly used as an admixture with wool.

The fibre of New Orleans cotton varies in length from $\frac{1}{500}$ to $\frac{1}{1500}$ of an inch in diameter. About 40 of these fibres compose a thread of "No. 38" cotton yarn. Ordinary printing cloth has, in the bleached state, 493 lineal feet of fibre, or 10.6 square inches of external surface of fibre, in a square inch, or of 1 grain in weight.

Cotton has a specific gravity of 0.8.

It requires nearly $3\frac{1}{2}$ lbs. of seed cotton to produce 1 lb. of staple.

There is no regularity in the length of the fibres, as every seed has attached to it fibres which vary in length one-half or more. Although tubular in its normal state, the fibre presents a flattened appearance after being packed, and when examined under a microscope it is of a ribbon-like shape in some portions, while in other parts the tubular form is quite visible. Some sorts of cotton fibre run as high

as $\frac{1}{3000}$ of an inch in diameter, so that there is a wide difference in quality, and abundant scope for study in regard to its varying degrees of utility and economy as an admixture with wool. Cotton gives a harsher feel than fine wool, but, as with the latter, so with the former, this can be lessened by thorough carding. Long before it became so common as it is now to mix cotton with wool its spinning properties had tempted a few shrewd manufacturers of fine woollen yarns to avail themselves of it, and for some years the secret of its use with merino wool was well kept, much to the enrichment of the sagacious ones. A single pound of Egyptian cotton has been spun to a length of 238 miles, 1,120 yards of yarn.

Much prejudice has existed against the use of cotton with wool, and at the present time it is generally considered as great a sin as to use shoddy. When judiciously performed there is no doubt that for some classes of goods an admixture of cotton is of great utility, and actually adds to the real value of the goods. There is then no just reason for the existing

prejudice against the use of cotton in woollen goods, and its economy is its full justification. At any rate every wool-carder who hopes to succeed with such admixtures must add to his knowledge of wool and wool-carding some adequate knowledge of cotton and its treatment.

The animalizing of vegetable fibres, which at this moment is occupying some of the best minds in Europe and America, is only a question of time, and when it is accomplished great things will doubtless follow.

COTTON STATISTICS.

The following table shows the amount of cotton consumed in the world in 5 years, ending in 1830, and in same length of time ending in 1875:—

	1830.	1875.
Great Britain . .	212,300,000 lbs.	1,228,600,000 lbs.
Continent of Europe	92,600,000 "	856,600,000 "
United States . .	38,500,000 "	524,700,000 "
Total for the world	333,400,000 "	2,609,900,000 "

Showing that it had multiplied itself nearly 8 times in 45 years.

The number of cotton spindles in the world has increased from 47,800,000, in 1860, to about 70,000,000 in 1880, as shown in the following table: —

	1860.	1880.
England	29,000,000	39,530,000
North & South America,	13,000,000	19,000,000
Continent of Europe .	5,500,000	10,000,000
India	338,000	1,250,100

The power-looms of the world produce annually of cotton cloth 10,000,000,000 yards.

The average consumption to each inhabitant of cloth amounts in America to 40 yards; in England 30 yards, and in China 20 yards. Taking the Chinese average it would require far more than double the number of power-looms at present in existence to supply the world with machine-made cloth.

The Cotton Manufacture of Great Britain.

[Compiled from the Census and Factory Inspectors' Returns, 1880.]

Number of factories . . .	2,674
" " proprietors . . .	2,500
" " spinning spindles . .	39,527,920
" " doubling spindles .	4,678,770
Total spindles . . .	44,206,690
Number of power-looms . .	514,911
" " females employed .	297,431
" " males employed . .	185,472
Total persons employed . .	482,903

This gigantic industry is concentrated in the four counties of Lancashire, Yorkshire, Cheshire and Derbyshire. In 600 of the above establishments spinning and weaving are both carried on; in 1,159 spinning only, and in 765 weaving only is done. There are 153 doing neither spinning nor weaving.

The number of spindles in Lancashire are about four times more than the rest of the United Kingdom.

England exports about 78 per cent. of her cotton manufactures.

Cotton Manufacture in the United States.

Number of spindles . .	10,500,000
Gross pounds of cotton consumed	698,000,000
Product in pounds of cloth, yarns, etc.	586,000,000
Equal in yards to . . .	2,637,000,000
Yards per pound . . .	$4\frac{1}{4}$
Export of manufactured goods, in pounds	38,684,000
Export of manufactured goods, in value	\$11,435,000
Export per cent. of the production	$6\frac{2}{5}$
Amount of capital invested, about.	\$208,000,000
Average count or number of yarn produced, about .	29
Value of imports of cotton goods, about . . .	\$30,000,000

Between 1838 and 1876, an interval of 38 years, the cost of labor per lb. of product was reduced 40 per cent., and the production per operative was increased 330 per cent.

In Massachusetts, in 1865, 24,351 hands produced 175,875,000 yards of goods, being a ratio of 7,355 yards to each employé. In 1875, 60,176 hands produced 874,780,000 yards, or 11,213 yards to each person. Or, as a result of the application of machinery, the quantity of cloth was increased nearly 392 per cent., while the number of hands were increased only 149 per cent. in the 10 years.

The two principal seats of the cotton manufacture in America are at Fall River and Lowell, in Massachusetts, a few interesting particulars of which may not be amiss.

Fall River contains 33 Incorporated Companies, with a combined capital of $14,690,000, owning 45 mills, containing 1,364,191 spindles and 32,621 power-looms. Number of persons employed, 15,055 ; cotton worked up, 162,500 bales into 391,750,000 yards of cloth annually ;

38 of these establishments manufacture print cloths, and produce 155,000 pieces weekly.

Lowell now contains of cotton, woollen, and carpet manufactories and machine-shops about 100. The first mill was established in 1823. The capital invested amounts to $17,000,000. Whole number of spindles 800,000, and of power-looms 18,261; hands employed 20,000, who work up 1,000,000 pounds weekly into 3,500,000 yards of cotton cloth. There are 72 steam engines of 9,800 combined horse-power. 92,076,000 yards of cloth are dyed and printed per annum.

American Cotton Cultivation.

STATES.	Acreage, 1879.	Acreage, 1880.	Increase per Cent.	Estimated No. of Bales.	No. of Spindles in the South.
North Carolina........	624,089	661,534	6	230,000	93,000
South Carolina........	985,370	1,054,345	7	350,000	92,000
Georgia	744,048	1,883,571	8	750,000	87,000
Florida	222,705	229,386	3	60,000	62,000
Alabama..............	2,122,422	2,292,215	8	775,000	63,000
Mississippi	2,117,101	2,180,614	3	975,000	70,000
Louisiana.............	1,285,250	1,336,660	4	600,000	6,200
Texas	1,684,631	1,886,786	12	900,000	9,300
Arkansas	1,132,886	1,212,188	7	350,000	1,700
Tennessee	761,460	875,679	15	250,000	49,000
Other States	......	......	..	450,000	200,000
Totals............	12,679,962	13,612,978	7.36	5,690,000	773,200

There are in the above-named Southern States about 183 cotton mills, mostly small, but rapidly increasing in size and number.

The crop of 1879 amounted to 5,073,531 bales.

Of this amount there was exported 3,467,565 bales.

The crop for 1880 is estimated at from 5,690-000 to 6,000,000 bales.

Of the Indian cotton crop there was received in Bombay, in 1880, 1,158,000 bales. Of these 338,000 were shipped to England, and 521,000 to the continent.

The Egyptian crop of cotton in 1880 amounted to about 151,322,052 pounds.

The amount of Brazil's donation was 28,625,-160 pounds.

To tie the Cotton Crop. — About 75,000 miles of hoop-iron — enough for a threefold girdle around the earth — will be needed for the estimated crop of 6,000,000 bales in 1880. There are 6 bands to each bale, or 36,000,000 in all. They are each 11 feet in length, and 1,200 weigh a ton. Hence there will be re-

quired 30,000 tons of hoop-iron, of a total length of 396,000,000 feet, costing about $3,000,000.

The largest cotton mills in America are the Harmony, at Cohoes, N.Y., which run 275,000 spindles. The largest in the world are at Narva, on the Gulf of Finland, in Russia, 81 miles from St. Petersburgh, and one company there runs 400,000 spindles.

In the Bombay Presidency, in India, there are 50 cotton mills, with a capital of $16,750,000, employing some 28,500 people. All these mills have been erected and worked with native capital.

The first steam cotton factory was established at Kurla, in 1863, and in addition to the mills above mentioned in the Bombay Presidency, there were in Calcutta 4, in the North-western Provinces 2, and in Nagapore 1, with a total number of 1,250,000 spindles.

FLAX.

Flax is the strongest and most perfect of vegetable fibres, according to M. A. Renouard, who has investigated it. The fibre is very di-

visible, and easily separates into a great number of threads by simply rubbing between the fingers when dry. Seen under a powerful microscope the fibre has the appearance of a glass tube, of uniform diameter, and the central channel running through its whole length is sometimes distinctly seen; at other times it is fine and cannot be perceived. The diameter of the fibre varies from $\frac{1}{800}$ to $\frac{1}{3800}$ of an inch. The joints which occur in the glass-like tube at the rate of from 400 to 800 per inch (the finest fibres having the most) appear to divide the fibre into a series of sacs, which in the living plant are filled with a fluid that plays an important part in the development of the fibre.

There are in Europe 3,482,300 acres employed in the cultivation of flax, producing 486,969 tons annually, in the manufacture of which 3,494,533 spindles are employed.

HEMP.

This plant is similar to jute, and belongs to the nettle family of plants. It shows no cellular construction, but seems divided into a number of longitudinal divisions.

Hemp comes next to flax in richness of fibre, but shows a less regular construction; the fibres are less independent of each other, and have a more varied appearance.

Hemp and flax when mixed do not make desirable goods, from the difference in the construction of their fibres; the flax becoming disengaged after several washings, and being cut by the hemp fibres, which remain in rigid and compact bundles, only separable under unusual circumstances; and herein lies the difference between these two fibres.

It has been found that the average diameter of hemp fibres is from 0.013 to 0.052 millimeters.

JUTE.

In 1796 the East India Company imported some small quantities of jute, and afterwards continued to import it in small lots now and then; but it made no progress with the manufacturers. Some of it found its way to Abingdon, in Oxfordshire, where there were a few manufacturers of sackings and woollen carpet-

ings. There it was spun by hand, and used to a small extent in their fabrics. To the Abingdon manufacturers, therefore, is due the credit of making the first introduction of jute into textile fabrics.

About 1833 some of this yarn found its way to Dundee, and attracted attention, resulting in the establishment of the manufacture which has since met with such extraordinary development in Great Britain, Ireland, and the continent. The increase in the consumption of jute during the last 50 years is most remarkable.

The total export from Calcutta in 1829–30 amounted to 20 tons, valued at £50; it has now risen (in addition to the enormous consumption in Bengal itself) to 350,000 tons, or nearly 2,000,000 bales annually, worth £6,000,000. Jute is mainly grown in Bengal, and exported from Calcutta.

The plant varies very much in color, gloss, cleanliness, and length. The best qualities are very divisible, of a pale yellow or silver gray color, and glossy. The fibre is from 7 to 9 feet long, and has been found up to 14 feet in length.

The plant is an annual, being sown in April and May, matures in 100 days, at which age it attains a height of 12 feet, and the thickness of a half inch. The fibre is situated between the stem and bass, or skin. Where small hard particles of bass adhere to the fibre it is useless to the carder, as the particles cannot be removed by the carding machine. Kept in a close condition it loses its gloss. Seal oil is used to soften the fibre, and so is petroleum; but the smell is objectionable.

Under the microscope it appears to consist of an agglomeration of uneven tubes, or longitudinal cells, whose inner surface does not follow the outside; so that the tube is of varying thickness. Its nature is hygroscopic, and the yarn from it still more so, which offers a loophole for dishonest practices to catch the unwary.

The yield of jute is from two to five times that of either hemp or flax. The average yield should be from 2,000 lbs. to 3,000 lbs. per acre. Enormous quantities are used in the manufacture of carpets.

Jute is the cheapest fibre known; hence it is

used in a great variety of fabrics suitable for every market in the world. It is in the coarser numbers made into all kinds of bags, sacks, etc., for the conveyance of raw materials of every kind.

The finer qualities of jute yarns are woven into tapestries, curtain cloths, and for upholstering furniture (such as the "Kalameit," now produced by the Barrow Flax and Jute Works), which is one of the largest concerns in the world for the manufacture of jute and flax. The jute fibre is also largely used in combination with cotton, silk, and woollen yarns in the weaving of numerous ornamental goods, and in the manufacture of telegraph cables, oil-cloths, linoleum, ropes, twines, cords, etc., down to artificial hair.

The finest jute yarns weigh about $\frac{1}{4}$ lb. per mile, while the coarsest will weigh 30 lbs. to the mile.

I have gleaned many of these facts from a paper read by Mr. William Fleming, of Barrow-in-Furness, 1880.

India exported of jute, in 1874, 1,000,000,000 pounds.

The United States pays about $1,000,000 for manufactures of this fibre in whole or in part.

About 3,200,000 spindles are employed in the spinning of jute in Europe.

RHEA FIBRE, OR RAMIE.

In 1810 3 bales of this fibre were sent to England, by Dr. Buchanan, and spun into yarn, which proved to be three times the strength as if made from Russia hemp. Flax machinery was imported by the East India Company into India; but it could not be prepared commercially with success.

Colonel Jenkins discovered the plant growing wild in Assam and sent a few plants to Calcutta in 1840. In 1869 the British Government offered $25,000 for a machine that could prepare the fibre at a cost not greater than $75 per ton. The best machine brought out fell far below the stipulation, but it was thought of sufficient value to award the inventor $7,500. In 1877 the government again renewed its offer.

The fibre grows in a wild or cultivated state in tropical Asia. It is perennial, and grows to a height of about 4 feet. The useful portion comes from the inner bark, which is picked apart by hand, requiring a whole day to prepare 2 lbs. of fibre. When ungummed, bleached, and combed it forms the strong and brilliant staple now used in the manufacture of Japanese silk. The fibre varies in length up to 10 inches; there is no joint or break in its continuity; it is of a nature to readily assimilate with wool, and has the fineness and gloss of silk of sparkling whiteness. It offers great resistance to water and damp. Three crops can be raised per year, yielding 500 pounds per acre. It is longer, stronger, and more uniform than flax, hemp, or cotton, to which it is equal in flexibility. It is inferior to silk only, and to its many advantages must be added its brilliant lustre and sparkling whiteness.

CHINA GRASS.

This is closely allied to the Ramie plant, and is used to a far greater extent as an admixture

with wool than is generally known. It is worth from £20 to £100 per ton in England, and is said to lose about 35 per cent. in working up. It is mixed with wool in the proportion of 10 to 20 per cent. being added at the picker or card. It will not take a wool dye, and being of a fine glossy nature it follows that a very good effect can be obtained in certain mixed goods by its use. The proportion of china grass must not be increased to that extent as to interfere with the milling or fulling of the goods. It can be used as a substitute for silk waste, and its price is somewhat ruled by the latter.

CHAPTER III.

RE–MANUFACTURED FIBRES.

SHODDY.

Dr. R. Schlesinger, says of shoddy that nowadays when cotton, wool, silk, and linen, are found in the same thread, it becomes an interesting question whether the wool is new or shoddy. The microscope seems to be the only means of ascertaining the nature of shoddy fibre. When examined under a microscope magnifying 100 to 150 times shoddy is seen to contain both colored and colorless fibres, the latter rendered so by reason of bleaching processes. Shoddy never shows the uniform and regular structure of new wool, but a series of sudden or gradual contractions, and equally sudden bulges in different places. The scales are often wanting, and the fibre seems to be stretched to a smaller diameter in some places. Shoddy is more rapidly attacked by alkaline lyes than new wool. There is no doubt but the unequal

diameter of the fibre referred to, as also the colorless appearance, is the result of its having once been manufactured and probably worn to the utmost limit. This also accounts for the loss of the peculiar scales found in new wool; and this fact shows that shoddy must be deficient in felting qualities as compared with its prototype. This is, however, possibly made up to some extent by the number of ends present in shoddy, on account of the shortness of its fibres. Strictly speaking, shoddy is the outcome of "soft" woollens, such as stockings, flannels, knit goods of all kinds, and other fabrics which have not been felted or milled during their manufacture.

All that class of rags accruing from broadcloths, and other felted goods or "hard woollens," constitute when ground up what is known as "mungo." It was some years after shoddy was manufactured before the shorter and more difficult mungo could be utilized. The discovery of this article of commerce is due to George Parr, of Howley mill, near Morley in Yorkshire, and it derives its name from two vernacular

words, which, translated into English, mean "must go." It originated from a remark made by Samuel Parr, brother of the discoverer, who, being unable to persuade a manufacturer to purchase some of the material, wrapped up his samples, with the remark that it *mun go*. That he prophesied better than he knew is shown by the fact that in 25 years after that utterance there were annually used in England 50,000,000 lbs. of shoddy and mungo. The latter country is no longer pointed at as the only one engaged in the wicked adulteration of pure wool; but, on the contrary, all other countries try, according to their ability, to outstrip England in the use of this material. Of course the world grows wiser, and gradually the most obtuse come to see that the commercial value of these once waste substances settles their claim to the title of "valuable raw materials. The first manufacturer bold enough to undertake the experiment of its use was Mr. John Watson, of Hungerhill, Morley, in 1834, and his first cloth was spoiled by the presence of cotton threads; but they then set women to work cutting out

the seams, and finally, by indefatigable perseverance, established the manufacture which has since brought comfort and independence to thousands upon thousands all over the world. Whatever may be said by the detractors of shoddy and mungo, the indisputable fact remains, that it cheapens cloths, and enables thousands, nay, millions, to have a woollen garment who might otherwise be without one. It is, so far, a legitimate application of a waste fabric to useful industrial purposes, and its manufacture must be classed amongst the great industries of the world.

Economical science applied to woollen manufacturing seeks the utilization of every morsel of waste fibre, and the improvements in machinery constantly tend towards the more perfect manufacture of substances formerly looked upon as worthless.

EXTRACT.

This substance is derived from the action of chemicals on mixed fabrics containing both animal and vegetable fibres. The same process

is extensively applied in Europe, and to some extent in this country, to the raw wool, in order to destroy the burrs, seeds, grass, etc., which it is necessary to get rid of; otherwise the cloth would show specks, on account of the dyes used on the wool not acting on the vegetal substances.

Shoddy and mungo, as we have seen, are made from the rags of all-wool goods, and it was many years after their successful utilization before a process was discovered by which the cotton could be destroyed in rags having cotton as part of their formation. Such rags were cast away as worthless until about 1854, when the process of extracting was discovered at Batley, in Yorkshire. The practical fundamental principle of this process consists in the treatment of the tissue by means of a solution of sulphuric acid (4° to 5° Baumé's areometer) and the passing of the former through a stove heated from 125° to 140° C. Another plan replaces the sulphuric acid by hydrochlorate of alumina; but in that case the stove requires a somewhat higher temperature. All the pro-

cesses used may be classed in two categories, viz.: —

(1). Carbonization of the vegetal substances with liquid acids, salts, etc.

(2). Carbonization by the application of gases.

The former may be divided into three operations: —

(*a.*) Immersion of the wool or cloth into the diluted acid liquor of 3° to 5° Baumé.

(*b.*) Partial drying in a hydro-extractor.

(*c.*) Exposure to a temperature of from 200° to 300° Fahrenheit.

(*d.*) Removal of the acid for the application of dyes.

Where the second process is used the main feature is the introduction of muriatic-acid gas amongst the wool. The wool is placed on racks, in an air-tight chamber, where it is exposed to the action of the gas for three or four hours. The gas being now stopped, steam is let into the pipes, and the temperature raised to 212° or higher. All the apertures are opened after a short time and air introduced to remove

the fumes of the gas; then the wool is washed, as before indicated.

The first process is mostly used in one form or another for extracting rags, and the action seems to be that as the temperature is quickly raised the water evaporates from the rags, and the acid, becoming more and more concentrated, attacks the vegetable substances with increasing vigor, depriving them of their hydrogen, without which they are almost entirely carbon or charcoal.

It has been found that when wool is thus chemically treated, and afterwards made into cloth, it has lost much of its felting properties; and to overcome this it is now subjected to the carbonization, after being manufactured into cloth, that is, after the cloth has been milled; and this is very largely practised in England and on the Continent, as it is found much cheaper and quicker than the old plan of picking out by hand, known as "burling."

In the case of rags, after they have been dried they are taken to a machine, called a duster or willow, and subjected to the action

of a cylinder having coarse teeth, which beats the rags against a grating, knocking them to pieces, and forcing the vegetable matter through the bars, in the form of black dust, resembling powdered charcoal. The remaining threads (woollen) are now carded through a rather coarse carding-machine, kept for the purpose, from which they escape in an opened-out condition, ready to be mixed with wool; and they furnish an excellent material for some classes of goods.

For many years, however, manufacturers fought shy of extract, on account of its admitted lack of felting properties. The reason for this was, that the fibre so recovered was mostly that made from combing wools; and in the early stages of this new industry the microscopical hooks or barbs surrounding the fibres, and the preservation of which are so essential, had become partly or wholly injured or destroyed by the action of the acids used, or the mode of their application. Of late years this has been overcome, and there are dealers in extract who

can guarantee the felting properties of their material.

Another trouble was the color of extract, a sort of lightish brown, and the difficulty of obtaining light-colored fibre that might be dyed; but all these objections have been more or less overcome, by discharging the original color, and by bleaching, etc., so that extract can now be obtained of many shades of color suitable for almost any sort of goods.

The perfection of extracting vegetable fibres from mixed goods soon led to the extension of the process to the raw wool, for the purpose of getting rid of the "burr's" chaff, straw, etc., which all raw wool contains, and which is not only very difficult to get rid of, but leads to the destruction of much of the fibre in so doing. Burring machines, heretofore exclusively used, are now fast giving way to simpler, more effectual, and less injurious, chemical processes, which can be conducted on a large scale, entirely ridding the wool of every vestige of vegetal substance, and saving all that large quantity of fibre adhering to the burrs when they are re-

moved in the ordinary burring picker. By the improved processes the wool retains its felting properties, the staple is left practically uninjured, the color not affected, and the properties of receiving colors unimpaired.

There can be no doubt that, eventually, the chemical will entirely supplant the mechanical separation of vegetable substances from the raw wool.

There is now manufactured in England, of low materials, substitutes for wool, about 125,000,000 lbs., and in the United States about 25,000,000 lbs.

Besides the fibres hitherto mentioned, there is the South American llama, an animal closely allied to the camel, and bearing a sort of wool or hair, similar to camels' hair, and used for the same purposes. Among the fur-bearing animals furnishing fibre for textile purposes there is the neutria fur, forming the coat of quoiga, a small animal mostly found in South America. This fur has been used for hat-making since the beginning of the present century.

There is the fur of the beaver, and the rab-

bit, hare, coney, otter, seal, muskrat, and many others.

Among re-manufactured fibres there is that resulting from the grinding up of hard ends, which is neither more nor less than a good quality of shoddy, and its value is vastly enhanced by being operated upon by the Garnet machine, instead, as formerly, by the common rag-picker, which has a disastrous effect on the length of the fibre.

PART II.

PREPARATION OF THE RAW MATERIALS.

CHAPTER I.

WOOL–WASHING.

Every carder desiring to do the best of work should be able to know when wool is clean,— thoroughly clean,—and then insist on its being made so. My experience teaches that the number who can distinguish between wool tolerably clean and that which is perfectly so are very limited. Nor is it such an easy matter to distinguish the nice differences which exist as might at first be supposed. It is indeed a matter requiring careful practice and observation before that peculiar skill can be attained which enables one to judge when complete cleanliness has been accomplished. If it were the simple removal of dirt, then any washerwoman could tell you if the wool was clean; but the dirt might be got rid of, the wool appearing white, and yet not be half clean enough to undergo the process of carding. The real

difficulty is to eradicate the natural excretion arising from the body of the living animal, in the first instance, and with which the wool is charged in a degree proportionate to the fineness of the fleece. In combination with this substance there is found dirt of many kinds, but chiefly sand and other earthy matters, which render the task of getting rid of the combined impurities anything but an easy one, without at the same time doing serious injury to the delicate structure of the fibres.

Wool may be injured by being left partially clean, or by contact with powerful alkalies, or by immersion in a too highly heated scouring solution, and in many other ways through neglect or ignorance of those entrusted with the washing and scouring process. It is no wonder such things happen when we look at the sort of "help" generally intrusted with the work, and the means they employ. The only rule (as a rule) is rule-o'-thumb, and, with equal truth, the only test of temperature is finger test. Who can estimate the amount of fine and costly wool actually dissolved out of sight by bunglers, who

increase both alkali and temperature in proportion as the wool increases in fineness and delicacy?

The impurities it is sought to remove by the operation of scouring chiefly arise from the fact that the sheep draw from the land on which they graze a large quantity of potash, which is finally excreted from the skin along with the sweat. This peculiar potash compound is known as "suint," and forms at least one-third of the weight of raw merino wool. M. Chevreul, who has examined this wool, gives the following as its composition: —

Earthy matters	26.06
Suint	32.74
Greasy matter	8.57
Earthy matter fixed by the grease .	1.40
Clean wool	31.23
	100.00

It is easy to extract the suint, by steeping in water; and on the continent of Europe this plan is largely practised with good effects, —

the principal gain being, first, the saving of 30 per cent. of soap or other agent employed; second, improved quality of the product. It is further explained, that in clipped wools which have been long stored, or packed, the grease undergoes fermentation, which results in the promotion of acid products. When the wool is steeped these products are removed with the water, but if scoured without steeping the acid would react on the soap, giving rise to slimy matters which adhere to the fibres. It is the same with pulled wools, where lime has been used in the operation, which, if not first steeped, entails a considerable expenditure of soap, and the production of an insoluble scum that adheres to the wool.

In France the pasty residue obtained by steeping is evaporated to dryness, the residuum placed in retorts and distilled, whereby the organic acids are decomposed, and there results crude carbonate of potash, equal to at least 5 per cent. of the wool. Much gas is evolved during the operation, which is used in lighting the factory; also much ammonia, used in various

ways, and a product consisting of carbonate, sulphate, and chloride of potassium. These salts after separation pass into commerce.

Grease is found in the scouring-tub to the amount of from 5 to 15 per cent., varying with the quality of the wool, and mixed with the soda solution, partly saponified and partly as an emulsion, together with undecomposed carbonate of soda, and soda combined with acids in the perspiration. The difficulties of separating this grease are so various, and the results so unsatisfactory, that but little of it is reutilized, although many claims have been made for processes said to economically restore the grease. A German inventor recently claimed to have invented a process by which he succeeded in separating the scouring-liquor, when no longer fit for use, into three layers, by decomposition; the top one containing the fat, the middle one the impurities, and the lower one the soda.

The refuse from 10,000 cwt. of unwashed wool is said to contain the following ingredients, having about the annexed values: —

500 cwt.	crude potash, at $4.26	$2,130 00
160 "	saponifiable fat, at $5.68	908 80
340 "	unsaponifiable fat, at $4.26	1,448 40
225 "	soda (being 45 per cent. of 500) . .	798 75
		$5,285 95

The agents used for scouring wool are many and various, some not only worthless but highly injurious; others, while possessing some advantages, might be profitably dispensed with.

PUTRIFIED URINE has been extensively used, and many manufacturers prefer it, as it contains a considerable quantity of carbonate of ammonia, which is a very mild alkali. The organic matter in the urine appears also to assist in cleansing, and protects the woollen fibre from injurious action by alkalies. The difficulty of obtaining stale urine in sufficient quantity, and its offensive odor, has diminished its use.

AMMONIA is also a mild alkali much used, and the best for treating wool is that distilled from urine. The crude ammonia distilled directly from gas liquor frequently contains hydrocarbons and sulphide of ammonium. The former act strongly on the hands or skin of the

workman, and the latter act injuriously on the wool.

Carbonate of Soda is the most extensively used scouring agent, and it enters largely into many detergents bearing fancy names. The following are the principal forms in which it is employed in woollen manufactories: soda ash, containing from 30 to 52 per cent. available alkali (oxide of sodium), soda crystals, containing 21.7 per cent. available alkali. The value of these substances as detergents is in proportion to the available alkali which they contain.

Soap is also extensively used. It is composed of a fatty acid in combination with soda, or potash, water, and impurities of no use as detergents, if not injurious to the wool.

The value of a soap consists in the correct proportions, and the amount of fatty acid and alkali. A good soap ought not to contain more than from 10 to 12 per cent. of water. To determine the amount of water in a sample of soap it is only necessary to dry a given weight of it at a moderate heat, and then reweigh it,

when the difference in weight will show the amount of water added. It is important to demonstrate this point, for soap can be made to take up from 50 to 100 per cent. of water without losing any of its solidity or hardness, and in that case the purchaser is paying what may appear to be a cheap price, but receiving therefor only half the weight in soap, and the balance water.

Silicate of Soda — Soluble Glass — Water, Glass, etc., is a valuable detergent for wool, which it cleanses very satisfactorily, leaving the fibres in good order for receiving colors, particularly the anilines. The wool scoured with silicate of soda must always be thoroughly squeezed between rollers, to which considerable pressure is applied before going into cold water, and this is a very important point; for if the silicate is not removed as directed it coats the fibres with a thin film, which resists the fixation of colors if the wool is to be dyed, and of sulphur, or other bleaching agent, if it is to be bleached. Silicate of soda may be used either alone or in combination

with common soda. The quality varies in proportion to the amount of silica it contains, — the larger the amount, the better it acts as a scouring agent.

The old-fashioned way, and the best probably for the wool, is to scour it in a round tub, provided with a false perforated bottom, resting on strips, and from 6 inches to a foot from the bottom of the tub. A steam pipe passes down one side of the interior of tub, and ends about 3 inches below the false bottom, the perforations in which will have to be governed by the judgment of the parties themselves as to size and distance apart. But they should be arranged so that while preventing the wool from passing through they shall allow the sediment and filth to freely pass, so that fresh wool cannot come again into contact with it. A false bottom made of wood $1\frac{1}{2}$ inches thick with $\frac{1}{2}$-inch or $\frac{3}{8}$-inch holes bored smoothly through, about 1 inch apart, will do, or it may be made of $\frac{1}{4}$-inch mesh, heavy galvanized wire netting fixed to a round hoop, and strengthened by cross-bars or rods crossing each other at right angles be-

neath the netting, so that the latter shall be smooth on the top. A post fixed to the centre of the tub will support the netting as well as the strips before referred to. In any case this false bottom must be an easy fit, so as to be removed, when necessary, to cleanse the filth out beneath. A couple of stout wires, on opposite sides, in the form of handles, which will lie flat except when needed, may be employed to lift out the perforated or netting bottom conveniently. On the top of this tub, which may be 5 feet deep and 4 or 5 feet in diameter, is fixed a slanting platform to the right of the operator, and projecting from the tub, provided with sides 6 inches deep, across which strips of wood may be nailed, the whole forming a rack, or "*scray*," on to which the wool is thrown to drain before entering the clear water to be rinsed. After the wool has steeped or drained upon the scray, it can be passed through pressure rolls to further squeeze out the scouring liquor, or, in the absence of these almost indispensable necessaries, it may be thrown into the "rinse-box." This is a long, rather narrow,

and deep box having a perforated bottom of copper, with holes $\frac{1}{16}$-inch diameter, and as close as may not interfere with the strength of the copper sheet. Here the wool is agitated with a stick or wooden fork, in clean water, liberally supplied, until the scouring liquor is washed out along with the impurities it has liberated. In large establishments wool-washing machines are employed, which, while not calling for any remarks here, may be recommended on general principles, for getting through large quantities of work with but little labor, and giving satisfactory results where reasonable intelligence is bestowed in their care, and in the preparation and care of the liquors employed, and if unlimited quantities of water can be had,

Washing and scouring by hand as described will enable one man to cleanse from 500 to 1,000 lbs. per day. The idea should always be not to crowd a large amount of wool into the tub at one time, but allow abundant room for working the wool continually, employing a straight hickory stick, operated so as not to twist or entangle the fibres, but to open and

expose them equally to the action of the scouring solution. The temperature to be employed is equally important with the detergent, and no rigid rule can be given; but for coarse, free wools, from 90 to 130° F, and for fine wools from 130 to 140° F, may answer. Always use a thermometer; then you will know what the heat is, and will soon become familiar with the best heat for certain wools and liquors without forever guessing, and never knowing.

Where water is scarce, a plan has been adopted, as follows: a perforated sheet-iron shell is swung from a trunnion and hung from a crane. The unwashed wool is placed in the shell and lowered into the scouring liquor, where it is agitated for a sufficient period and then drawn out by the crane. The shell or basket is allowed to remain a short time suspended over the scouring vessel for the surplus liquor to drain, when the crane is swung around over the wash-off or rinse-box, the shell tilted up, and the wool discharged into the fresh water. Two men are required; and while one is rinsing the other is scouring a fresh supply.

Tepid water is generally the best for rinsing purposes, but especially when silicate of soda is the scouring agent. The wool will then look whiter, handle softer, be more open and free, and, therefore, more susceptible to the action of dyes or bleaching agents than if washed off in cold water.

Wool not well cleansed will neither card nor spin with satisfaction, nor will the cloth made from it "mill" or "full" evenly; it will prevent the thorough penetration of the dye, taking, instead, a daub, that will wash streaky in the cloth, which will handle sticky, and cannot be made to assume a satisfactory look, with a clear and distinct color, and clean, showy appearance.

The less greasy the wool, and the larger percentage of soda required, is another point worthy of note. The clear liquor from an old scouring bath is a good thing to use in starting a fresh solution, as the grease it contains acts as a solvent of the grease in the wool.

If the water is "hard," more soda, etc., will be required than would be necessary with soft

water. To judge when the liquor possesses the right degree of alkalinity, it is best to first dissolve the detergent in a pail of boiling water, with constant stirring until dissolved, then keep adding it to the fresh scouring liquor previously heated to 100° F, until it feels soft and smooth to the fingers when rubbed together in contact with it. A sample of wool can now be dipped, shook about, withdrawn, and squeezed in the hand several times. If it springs elastic on being released, and has seemed to part, with great readiness, with its dirt and gum, and it feels silky, and looks loose and free, then the liquor is in good condition for that kind of wool. The operator must use his judgment in case the wool does not appear satisfactory, as to whether it is the temperature which requires increasing or diminishing, or the scouring agent he employs. By the constant use of a thermometer, the question of temperature is an easy one, and will become indispensable to maintain a constant heat in the continually cooling solution caused by the addition of fresh wool. By adding fresh water as the liquor runs down, a

small addition of the solution in the pail (which should always be kept on hand) may at times be necessary; then the heat brought up to the standard found best for the quality of wool in hand, by the use of the thermometer, and you may use the same liquor until it becomes foul beneath the false bottom and requires entire renewal.

Washing Waste.—For removing mill grease from waste, caustic soda is employed, and if soap is used it should be made with caustic in preference to carbonate of soda, which does not combine well with grease, and merely forms an emulsion. The waste should first be picked or dusted, and the temperature of the bath about 130° F. to 150° F. Spirit of ammonia, of 18° B., is added to the caustic soda, and the waste steeped therein, then stirred about, and finally rinsed in clean water. Soda-ash is often employed as above, sometimes with and sometimes without caustic soda and ammonia.

Woollen fibres should never be suddenly changed from hot to cold; always allow time to cool after leaving the scouring liquor, or use

tepid water to rinse with. When wool is thrown too quickly from hot into cold water it contracts, and then the grease, loosened in the hot liquor, becomes fixed to the fibre by the sudden chill and consequent contraction.

For the purpose of ascertaining the difference in cost of wool after it has been washed, as compared to its first cost, a simple rule is, to multiply the greasy pounds by the price, and divide by the clean pounds. Example: If 16 ounces of wool cost in the grease 42 cents, and after washing weighed 12 ounces, the clean cost is:

16 ozs. greasy wool,
42 cents per lb.
Clean wool 12 ozs. | 672
56 cents per lb.

CHAPTER II.

BLENDING OF TEXTILE FIBRES.

BLEND.

[Anglo Saxon.] To mix together; hence to confound so that the separate things mixed cannot be distinguished. — *Webster.*

In these degenerate times a carder has many vexations his brother in years gone by knew nothing of, and the blending of different textiles is assuredly one of them. The modern carder can, however, console himself with the reflection that there have been no innovations in the method of blending, for it has always remained in the same good old way, discovered by the fellow who first mixed a lot of wool and dirt together.

If there has been any improvement made in this direction we have not heard of it.

To the novice nothing would seem more simple than to throw different fibrous materials together, and shake them with a stick; but what a mistaken idea it is every practical man ought

to know, but apparently does not, for, in the majority of cases, it is only novices who are ever entrusted to do it. It is disagreeable to be obliged to acknowledge the fact, that not in one mill in a score, in this country, is the great importance of thorough blending properly appreciated, or, at any rate, executed.

There are men who will bestow every care in setting their cards and grinding them, who will make great efforts to get the best possible results from a lot composed of several materials widely differing in every respect from each other; and these same men will leave in the picker-room (to carry out a process not in any sense secondary to grinding or setting a card) a fellow who the less he knows the more he is thought to be worth in a place of that kind. The cards have been brought into gilt-edged condition, we will assume, and the carder has devoted himself to get them into prime shape, which done, the mixture — having meanwhile, been fed on the picker alternately, wool, cotton, shoddy, etc., by guess — is brought into the card-room, and the result is, that all the time and

care bestowed on the cards prove only to have been misdirected effort; for it has accomplished nothing towards getting a perfectly homogeneous thread, that end having been utterly defeated in the picker-room, and past all remedy.

If a thread resulting from such bungling could be examined for a considerable length, under sufficient magnifying power to clearly show the nature and construction of the several fibres composing it, there would be revealed, instead of a perfect amalgamation of each individual fibre, a mass of cotton fibres in one part, wool in another, etc., producing effects that render it utterly impossible to draw such a thread "even" under any circumstances. These remarks apply with redoubled force when the blend consists of part animal and part vegetal substances. To get reasonably fair results from such admixtures there must be perfect amalgamation; else how can it be expected otherwise than that each of the substances will assert itself in passing through the carding and spinning, to the destruction of any regularity whatever in the thread or yarn?

All kinds of textiles do not require the same amount of carding; therefore if two classes of material are mixed together this should not be lost sight of, for the closer the character of the mixed fibres the more perfect will be the yarn. The length to which the yarn is to be spun must also be considered, for there is a limit, and one portion of the batch might be quite able to be drawn to the requisite degree of itself, but could be entirely spoiled by an unsuitable mixture of some other fibre. It is very easy to make dear yarn from cheap stock, and many have found that out. It is not the low price or larger quantity of poor stock one can crowd in, but rather the percentage of yarn resulting from the batch, and the cost in labor of its manipulation, that is the vital question. So much is charged, for instance, to carding and spinning; but if it takes as long to spin 100 lbs. of inferior yarn as it does 150 lbs. of good yarn, then the economy is questionable. An English writer has truly said, "It is not wisdom to take material, although low-priced, and try to make it go to a greater length than it is really fitted; neither is

it always on the side of economy to take the cheapest material that will go comfortably to the length required." A story is told of a "manufacturer, who was using a considerable quantity of 24 skeins ($4\frac{1}{4}$ run) black weft, and he wanted to make it as cheap as possible to have a good yarn. He put in wool dyed black, costing 2s. 9d. per pound, along with a 7d. mungo. The cloth proved to be tender and poor, and not at all up to the mark. He then put on another lot, in which the black wool cost 3s. and the mungo 9d., and the high-priced material produced yarn $1\frac{1}{2}$d. per lb. less money than the ~~high~~ low-priced material, and the cloth was all that could be desired." Another point of the greatest utility in the thorough blending and preparation is to feed the picker — *thin.* What is the use of crowding it through, and thereby converting your cards into auxiliary pickers and preparers? It is certainly economy to spend a little extra time, and have the wool as well prepared as it is possible to have it, and thus save waste of both stock and card clothing, besides making better work. The difference

between a successful and unsuccessful carder is often traceable to his care in the picker-room.

We will now give the latest practice in mixing various fibres, and then such items as may seem of value in reference to oiling *per se*.

HOW TO MIX WOOL AND COTTON.

Perhaps there is no better way than that which is followed in Belgium in the manufacture of "Vigogne" yarn, meaning half wool and half cotton, the latter being generally the better half. Both the wool and the cotton ought to be of good, sound staple.

The wool should be fine merino, and the cotton clean Sea Island. It is of the greatest importance that the wool should be thoroughly clean, scoured, carefully dried, willowed, picked, and oiled. Then it should be carded through the ordinary breaker card and wound into a lap on a drum placed in front of the doffer, which, as well as the workers, should have a slow movement imparted to them, be as smooth as possible, and to a good working point, so as to obtain the most thorough carding; or, in other

words, to get the wool as straight as possible and free from every sign of "nub" or "cockle." The laps can be laid one on the other until wanted.

The cotton should be well cleaned by passing through the common opener-lapper, and the lap fed to an ordinary cotton card. A woollen card will answer, but the cotton card is best. The slivers from a number of the latter may be run together and afterwards "picked," to facilitate the mixing, or the cotton may wind on a drum as for the wool. The object in carding it is to get it straight and clean. The cotton may, however, be taken from the lapper direct and mixed with the wool if the goods do not require to be so perfect. In any case, after both the cotton and wool have been prepared, the desired proportion is weighed out, picked separately, and then blended together and picked once or twice again, when it is ready for the final carding through the ordinary woollen cards and condenser.

There is a very successful hosiery mill in this country, where the above has been followed for

years, and they make excellent yarns, free from specks, and very uniform in texture.

Another and easier plan is to first weigh out the proportions wanted; then pick the wool, oil it, and pick again; then pick the cotton, and carefully blend them together, when pick once or twice again. The cotton will absorb a little oil from the wool, and get as much as is good for it. It is a very good plan when mixing these two fibres together to run them through a burr-picker, both before the wool is oiled and at the final operation; but the common picker answers well enough to simply mix the two after blending, always provided that when the stock is brought from behind the picker, either to be again picked, or to go to the cards, care is taken to again blend that which is in the middle of the pile and that which is on the edges. Whatever the kind of stock in hand the principle to be observed in blending always is to *lay out evenly and thinly over a large area as many layers as practicable.* That is the whole subject in a nutshell. The batch should be well beaten down with sticks,

and when any is taken from the pile *always take it vertically from the edge*, and *never from the top*.

HOW TO MIX SILK WASTE WITH WOOL.

The first thing to be observed is that the silk waste must have the color of the ground of the cloth to be manufactured, and never that of the mixture which may be added. If, for instance, a lot is made up to consist of 75 per cent. black and 25 per cent. white, then the silk waste must form an addition to the black. It is important that the wool and silk be free from grease and gum, or the silk will be likely to mat together and felt. Oleine, if free from acid, is the best material for oiling. Silk being more difficult to card than wool renders it of the first importance to have the card-cylinders very true, so they can be set close, to obtain good results. The doffers require great attention; they must be true, smooth, and sharp, and should run about 4 turns per minute. The fancy must gain but little (as little as practicable) on the cylinder, and all draft, as far

as possible, avoided. The speed of the main cylinder should not exceed 80 turns per minute. The silk is so light and "fluffy" that these precautions are necessary, as well as to avoid all unnecessary friction on the fibre, as it quickly becomes charged with static electricity.

A guiding principle in mixing stock of different kinds together is to never have great variance either in length or fineness. The nearer the fibres approach each other in length, thickness, etc., the better for the yarn. A finer thread may be spun from wool of an even length, though coarse, than if fine and short wool should be introduced amongst it.

CHAPTER III.

OILING.

Having now stated the principal points to be observed in the blending of fibrous material we arrive at an equally important requisite, viz., the thorough incorporation of the oily compound, whatever its nature, with the fibres.

Various plans have been tried, among which may be mentioned, oiling at the "picker," or "teaser," by mechanism applied sometimes at the feed lattice, and sometimes at the throat, or exit. Independent machines have also been devised, but the plan most generally followed is to perform the operation wholly by hand. Objection has been found to all of the above means, inasmuch as the material must lay in the oiled state during the carding operation, and therefore subject to evaporation, especially when the various compositions are in use; and also objectionable on account of the greasy material saturating the floors and increasing the risk of

fire. To overcome these drawbacks various plans to oil the substance at the feed lattice of the carding engine have been tried. Whatever the plan adopted, the object remains the same, namely, to lubricate the fibres so that they may not by abrasion or friction during subsequent operations injure the natural barbs with which each fibre is armed.

We have before drawn attention to the preservation of these delicate barbs for fulled goods in reviewing the construction of the wool fibre. It is of equal importance to evenly oil the wool for goods that do not require much, if any, fulling, for the reason that the fibres will destroy each other, by becoming interlocked, in passing through the cards. This is clearly shown, if a lot be run through the cards without oil, by the amount of flyings and droppings. In using one of the many compositions now so often applied to the wool with the object of saving oil by substituting water in combination with a saponifying agent, it is well known that the cards must keep up with each other, and the spinning be close after the cards, to avoid evapo-

ration of the watery part of such composition, which would occur if the wool was allowed to accumulate. In that case the effect is clearly manifested of want of lubrication during the spinning, although the carding may have gone on satisfactorily because the evaporation had not taken place to that extent as to become manifest. But the spinning would be imperfect and much fly be made, while the yarn would be less elastic, etc.

It is clearly evident, then, that a good quality of oil, pure and simple, applied to the wool in the most perfect manner, so that as near as possible all the fibres shall share alike the needful lubrication, is and must be the most economical course to pursue. The cost of the wool so far exceeds the cost of the oil, and as a scant supply, or inefficient application, of the latter must inevitably lead to a loss of the former, it is at once seen how false is the economy of wasting the wool to save the oil.

Which oil is the best for facilitating these objects is a question open to discussion. A German authority says that the substance which

is the cheapest, and, on the whole, gives the best results, is oleine. This lubricant is obtained by pressure from animal fats, and is known in the market as tallow oleine, lard oleine, and neats-foot oil. But the oleine we are concerned about as a substitute for olive or Gallipoli oil is derived from the manufacture of stearine candles. As a result of some of their operations there is produced a mixture of stearine and oleic acid; these are separated by means of sulphuric acid, the stearine being used in the manufacture of candles, while the oleic acid is made to give up its oleine, which is then freed from the sulphuric acid by distillation; and if the process is honestly conducted the resulting oil is free from acid and well adapted to the oiling of wool. If, however, the acid be imperfectly removed, which is often the case in cheap oils, seeing that the acid is heavier than the oil, then the card clothing will suffer, and the yarn be injuriously affected, destroying much of its felting properties. The girls who feed the cards, or otherwise handle the oiled wool, with bare arms, suffer from its effects if acid be present, and the

writer has seen in a large mill in Rhode Island, where they are supposed to know better, the effects of acid on the hands of several girls who had lost their finger-nails through feeding of the wool so contaminated. Commercial oleine always contains traces of the acid varying from $\frac{1}{2}$ per cent. upwards.

The RED OIL, now largely used for oiling wool, is somewhat analogous to the above, and has the same objections in reference to the acid. There are two kinds of this oil, one known as saponified, and one as distilled or "elaine," which latter is substantially the oil we have described. The saponified oil is not considered as being so suitable for wool as the other. It derives its red color from the iron of the presses used in its extraction, which is attacked by the free acid, and, becoming rusty, stains the oil. In the manufacture of this oil by the saponifying process, the lard or tallow is placed in an upper boiler, to which a lower one, containing water, is attached by two pipes. On the water being boiled, the steam rises upwards through one pipe, and through the mass in the upper

boiler, where, becoming condensed, it flows down the other pipe into the lower boiler again. After ten hours of this treatment, the grease becomes disintegrated, and separates into its component elements of stearic and oleic acid and glycerine. It is then put into bags and pressed, when the oil separates and runs into the receptacles beneath the press.

The elaine oil is obtained by distillation, the oil coming over, leaving the stearic acid in the still, which, after the oil has been extracted, is manufactured into stearine or "adamantine" candles.

The readiest way of testing oils for acid products is to place a drop on blue litmus paper, which will turn red if there is the faintest trace of acid. But this gives no idea of the quantity, nor does there appear any better way than to obtain a sample of oil as free as possible from acid, and have it analyzed, and then, by means of a hydrometer, compare its specific gravity with suspected oils. The oil will be heavier in proportion to the acid it contains. The principal advantages claimed for oleine refer chiefly

to its easy saponification, an addition of soda lye being all that is required to combine water with the oil, making not only a handy composition, but also an easy scouring oil, which is a very important point.

A good COMPOSITION may be made with oleine 10 per cent. and water 15 per cent. of the weight of wool to be oiled. The water must be boiling, and a little sal-ammonia added with the oil, sufficient to cause the oil and water to unite. If the wool is colored black, brown, etc., 10 per cent. of its weight of water will be found sufficient.

For yarns which have to lie a long time after spinning, and for the finest wools, nothing can equal good olive oil; but for the great majority of purposes, cost, and everything, it seems as if oleine answered the purposes of a useful oil for wool. Lard oil is still used extensively in this country, but not so much as before the advent and practical application of mineral oils, which, for many purposes, cannot be excelled; as, for instance, where the goods are sold unwashed, and a quickly evaporating oil is a desideratum.

After considerable experience the writer is of opinion that mineral oils will ultimately supersede the fatty animal and vegetable oils, as, in fact, they have already done to some extent. There is scarcely any risk of spontaneous combustion in their use, while with animal oils the danger is at all times imminent.

One of the readiest tests to determine the practicability of a wool oil is to add 40 parts of a solution of carbonate of soda, of 3° Baumé, to a portion of the oil, and stir well. If a milky emulsion is formed, without any oily drops on the surface, it is an indication of good greasing qualities.

It is not always that satisfaction is obtained in the use of oleine; but this may be the result of improper mixing of the oil and water, rather than in the oil itself. One manufacturer complained that, having taken two parts of one lot of wool, and greased one of them with 15 per cent. of olive oil, and the other with 16 per cent. of oleine free from acid, both being mixed with 20 per cent. of water and a little spirits of ammonia, although carded through the same

machines, the part with olive oil was soft, while the other was hard and dry, and gave an uneven yarn.

But it is asserted that if a mixture be made of 40 per cent. of oleine free from acid, 60 per cent. of water, and a cupful of spirits of ammonia, and well stirred, until a milky solution is obtained free from bubbles, and then thoroughly mixed with the wool, the results will be satisfactory. The water should always be hot, then the spirits of ammonia added, with constant stirring, and, lastly, the oleine, the agitation being constantly maintained.

Another Composition is recommended by Mr. Lebrun, in a German paper, who says that by its use a considerable saving of oil may be effected, besides insuring uniform results on account of the woollen fibres loosening and separating themselves more easily from each other; that it is not injurious to the color, of which the wool may be dyed, nor injurious to the card clothing, while the latter can be cleaned more easily and economically.

To obtain this preparation, pour into a wooden

trough or tub, 20 parts of oil, 10 parts liquid ammonia, and 5 parts of water. Stir up with a wooden stick or spoon, turn on the steam, and allow the liquid to boil until the strong smell of ammonia has evaporated; then proceed to oil the wool in the usual manner.

Elaine oil, once so much used, has been greatly neglected of late, the reason being that it contained so large a percentage of free acid that it spoiled the card wire, and rendered the goods harsh to the feel, and also weakened the fibre.

IN OILING WITH LARD OIL, a fair proportion to 100 lbs. of wool is 4 to 6 quarts, and a composition may be recommended composed of No. 1 lard oil 4 gallons, water 5 gallons, borax 4 oz. Dissolve the borax in warm water, then add the solution to the boiling water; agitate and then pour in the oil, amidst constant stirring. Boil a few minutes, and it is ready for use. 16 per cent. of the mixture will be found about right for ordinary purposes, but it is well to remember that the carder should not strictly follow any rule giving the amount of

oily matter to use on the wool, unless he has found the proportion best by his own experience, for the kind of wool he has to use, and the condition in which he finds it.

A rule for oiling wool that can be implicitly followed on every kind and condition of stock, and it is the only rule applicable in so broad a sense, is this: to always distribute the oily substance so that every fibre may as near as possible obtain an equal degree of lubrication. The relative per cent. of lubrication can only be learned by experience, but an excellent rule to follow is, *never stint the oil.* Wool is one thing in its natural state, and another thing altogether when colored, as it is also one thing when mixed with shoddy, etc., quite different from the simon-pure article, and all of these circumstances have to be taken into account. Each will be found to require a certain amount, less than which should not be given; more it does not need, and no more should be applied.

OILING WOOL AT THE CARD.

Many arrangements have been devised to oil the wool as, or just before, it enters into the carding engine. The objections to oiling large amounts beforehand, and allowing it to lay previous and during the carding process, cannot be allowed if compositions of oil and water, or mineral or other easily evaporating oils, are used; and it is a very doubtful question except, perhaps, for a few specialties, whether it is any advantage to let the wool lie in the oiled state; and it is undoubtedly a risk greater than if the wool lay unoiled. Then there are the greasy walls and oil-saturated floors, consequent to oiling at the picker, which, of course, always entails preparing considerable quantities ahead of the cards. The advantages sought in oiling at the carding engine, besides overcoming the above, are, in addition, calculated to perform the operation more evenly, and in a more easily controllable degree, so that the carder can, as judgment dictates, supply just so much, and no more, of the lubricant to his wool. There is no doubt what-

ever that the ideas and principles are correct as claimed, all favoring mechanical oiling as the carding progresses, and that great good would result if these principles could be perfectly carried out. That they have not been is no reason to debar the final success of others. To oil the wool after being spread upon the feed-table, and flattened thereon in a compact mass, is only a half-way attempt. This has been tried long enough, and, while not a failure in the full sense of the word, it has failed to be anything more than a makeshift. What is wanted, and demanded, is a means whereby all the fibres shall receive proportionate lubrication, the amount of which shall be under perfect control by the carder, and be applied at the carding machine. The device such as we refer to would have to be arranged so as to automatically shut off the oil whenever the card was stopped, and to commence again simultaneously with the starting up of the card. We consider it disgraceful that this critical operation should, amidst all the improvements of machinery, never have advanced a step.

OILING AT THE PICKER.

Next to oiling at the card I prefer this mode, and particularly at the exit, or throat, because a more uniform result can be obtained than the average result by hand-oiling. C. L. Goddard devised a revolving brush, placed immediately over the throat of the picker, arranged to distribute a spray of oil amongst the outgoing wool. It is made by Curtis & Marble, of Worcester, Mass., and applied to the Goddard Burring Picker. Several other similar arrangements are in the market, any one of which is to be preferred to a greeny dashing the oil on by hand indiscriminately. When a machine is used, however, the wool should be once more blended after the oiling, taking it alternately from the sides and middle of the pile and beating it down in alternate layers, and again running it through the picker.

OILING BY HAND.

To do this in the most perfect manner the component parts of the "batch" should first be picked, then blended, and picked again; then

as large a space as possible be cleared in front of the picker, and a *thin* layer *evenly* spread over the floor. The oil should be in a limpid condition, so as to flow freely, and distributed by means of a can having a spout provided with a cross-piece pierced with about four rows of small holes, the spout being thus in the form of a T, at one end of which a cap should be placed which can easily be removed for the purpose of cleaning the tube. This tube or spout may be $1\frac{1}{2}$ inches diameter, and the cross-head about 9 inches long. Before the oil is placed in the can it should be filtered through a piece of burlap, or bagging, folded two or three thicknesses, and placed on the can. Through this the oil should be poured, the can being previously cleaned. This will prevent the small holes becoming clogged, and will allow a steady series of fine streams to issue on to the wool, the can being carried in the hand and swung back and forth in such a manner as to *evenly* distribute the oil *thinly* over the material. Another thin layer of wool may now be distributed, and again oiled as before. At every second repeti-

tion the material should be beaten with sticks in every part, to thoroughly incorporate the oil and wool. The operation is thus continued until the whole is completed and ready to be again run through the picker. The wool should now be taken from the pile from top to bottom, and fed on the feed lattice thinly. If these instructions are *carefully* followed the wool will be as well oiled as is at the present time possible, and it is the carder's first duty to personally see, and insist, that it shall be so done ; for if he allows others, no matter whom, to look after this part of his affairs, he will have no end of trouble. Textile materials unevenly blended, or unevenly oiled, will, and must, make uneven yarn, and uneven yarn will be laid to the carder, to whom, beyond a doubt, the proper manipulation of his materials in the picker-room is of vital importance. It is not a question of expediency, but of a more serious nature, and he who alone will be held responsible must himself watch it with eternal vigilance, and trust to no one that which no one can as well as himself know the importance of.

OILING SILK WASTE.

The oil or composition should not come in contact with the silk, and the best way to proceed is to spread the silk evenly on the floor, then cover it with one or more sacks, and on these pour the water so that the silk becomes dampened by the portion which penetrates the bags. This will prevent too much flyings during the carding, and retard the electrical effects so troublesome in carding silk waste. When wool is mixed with the silk it should be oiled previous to the mixing, as recommended for mixtures of cotton and wool.

PART III

THEORETICAL AND PRACTICAL CARDING.

CHAPTER I.

THE CARDING ENGINE.

Taking a set of carding machines, all in all; considering the work done by them, and the ingenuity displayed in their make-up, as well as in the manufacture of the card clothing, and the mechanism employed therein; the widely different articles entering into their composition; the industries drawn upon to complete such a set ready for work, and the delicacy of the materials worked; the complex nature of that work, — and I think it only justice to place the carding machine foremost amongst all the great inventions of the last century.

The ingenuity of man's intellect cannot conceive a mechanism more perfect in its adaptation, more precise in its adjustment, or more accurate in its performance, nor yet requiring greater skill in its successful management, than this grand result of human perseverance.

Scanning the progress it has made from the earliest times, the numberless modifications it has undergone, and taking a comprehensive survey of the efforts which have been made by thousands of earnest men who, for generations, have devotedly delved into its intricate mysteries, it stands a marvel, without a parallel, amongst mechanical appliances.

Going back to the beginning we find that carding was performed by hand in the following manner: "A card, such as was used in the early stages of the manufacture, was more like a large brush, and this brush was composed of fine wire bristles, which leaned at a given angle instead of being straight. Two such brushes or cards were used together by the operator, having one in each hand; tufts of wool were placed on them, and by repeatedly stroking one brush against the other, the tufts of wool were straightened and lay amongst the wire bristles, which then only required to be taken carefully away from the card without disturbing the smoothness of the wool. These straightened tufts were called "cardings." After being pre-

pared in this manner, the carding was taken and spun by hand."

Equally primitive was the manufacture of card clothing. The mode of procedure was to prepare a sheet of leather 18 to 20 inches long, and 4 inches wide, which was ruled with lines at regular intervals, and pierced with a two-pointed pricker until the sheet was full of small holes. The wire was next cut with a pair of shears into lengths of about one inch, bent by hand into the shape of a staple, and next bent again, or hooked into the form of a card-tooth. These teeth were then taken singly, and put into the holes of the leather, and when the sheet was filled with teeth it was nailed on to a board having a handle, and was ready for use.

An improved arrangement for carding was brought into use prior to the invention of the cylinder machine, as follows: the head of the family would be engaged at what was then called "stocks," which consisted of a frame on an inclined plane. On the face of this frame were fixed coarse cards, on which was placed the wool. Sitting in front of the frame the

workman held in his hand a square board, also covered with cards, and with a see-saw motion over the inclined plane the fibres of wool were carded and prepared for being spun.

The first patent taken out for a carding machine was issued to Daniel Bourne, January 20, A.D. 1748, No. 628. "A machine for carding wool or cotton by hand or water," his specification reads. "The properties by which this machine for carding differs from any other method hitherto invented, are principally these: —

"That the cards are placed upon cylinders, or rollers, and that these act against each other, by a circular motion." . . . . "It may be observed that more or fewer may be put in a machine than four cylinders, though that number is found to be most proper. The cards are wrapped around the cylinders, which, by their circular motion, and at the same time their acting upon one another, card the wool or cotton sufficiently fine for spinning. The cylinders are mounted in distinct frames, fixed to sliding plates, by which they may be set at any re-

quired distance from each other, and by means of levers or rods the second or fourth cylinders are drawn to and fro in a sidelong motion, in order to disperse the wool or cotton equally over the cards."

Now this specification proves conclusively that Bourne had studied the subject pretty thoroughly. Lewis Paul obtained a patent August 30, 1748, No. 636, for a sort of flat surface card, showing a crude arrangement of levers, boards, string, and windlass, his specification being too long to transcribe, besides being of little interest.

The first patent for a card-clothing machine was dated Oct. 13, 1750, No. 157, and granted to William Pennington. He shows in his specification devices for holding the leather tight, a pricker to make the holes, and a dividing-wheel for regulating the distance of the holes apart for different kinds of wire, etc.

Robert Peele, February 18, 1779, No. 1212, describes the side drawing, "tube or funnel placed near the doffer for drawing off and slightly twisting the sliver."

Richard Arkwright invented the "doffer-comb," his patent bearing date Dec. 16, 1775. He was then connected with Strutt, and they seem to have invented the doffer at the same time.

The father of the first Sir Robert Peele had attempted cylinder carding in 1760; but the difficulty, of stripping the cylinder by hand caused its abandonment.

To Arkwright also belongs the credit of the invention of the workers and strippers, he having been the first to notice the advantage gained by returning the fibre. It is to Hargraves that we are indebted for the invention of the Fancy;" and this completed the carding machine.

On June 26, 1799, patent No. 2322 was issued to Clement Sharp and Amos Whittemore for a card-making machine, as follows: "The leaf or piece of leather is put into the stretching-frame, and by its different motions every part of it is brought alternately to a given point in the centre of the machine." . . . "On the machine being put in motion, a pair of

holes are made in the leaf; at the same time the proper length of wire is brought forward, and seized by its middle, when it is cut off and bent into the form of a staple, then conducted through the holes in the leaf, where it is crooked, let loose, and forced up to its place. The leaf is then shifted the space for the next staple, and the several movements again take place, and are repeated until a row in width is complete, when it is shifted the distance for the next row, which is completed in a similar manner, and so on until the card is finished." This invention completed the card-setting machine in its crude form.

The earlier carding machines were mostly made of wood. The "arches" were mortised for the poppet-heads, and wedges employed on each side of the latter. It was only necessary when setting the card to ease up on one wedge, and pound down the opposite one, to get things where you wanted them, until they shook loose again by the ram-shackle movements of the machine. Wrenches were not much used, and gauges never; the sharp eye of the boss was all

the gauge he needed, and when his eye "went back on him" he used his ear. Instead of graduated wrenches a mallet, but more often a hammer, was the implement of precision employed. These were the times when the patience of a Job would not suffice in maintaining one's temper. Nor was it wholly the fault of defective appliances; for there was a still more exasperating element in the small help of that time, who knew no organization, nor would they submit to any control, and it was fun for them to harass the overlookers, foremen, etc., to whom they were veritable imps of mischief, never happy unless raising the devil with the primitive machinery, in order to get out for a day or two, or in the hope of getting "sacked" altogether.

Little do the men of this day know of the great vexations, the soul-stirring trials, of these pioneers, who at one and the same moment were attempting the organization of the factory system, the adaptation of machinery, and the creation of a class of help totally different from anything hitherto known.

The great majority of these men were unlettered, but in them lay hidden the germ of the manufacturing prosperity of the world; in their crude way they were laying the foundation of a manufacture which, in course of time, would result in the production of machinery of wonderful accuracy, and fabrics of beautiful texture, reaching to the very ends of the earth in its influence, furnishing new industry and new incentives to millions of human beings.

Such, then, is a short history of the strides made in the development of the carding engine. We have seen that Bourne invented and patented cylinder cards one hundred and thirty-two years ago; that the doffer, doffing comb, fancy, workers and strippers, in other words, the counterpart of the present carding machine, were all perfected as long ago as 1773.

One would think that since that time we should have arrived at some well-established truths, from which a correct theory of such machines might be deducted. But, taking a survey of the manufacturing world, we find, on this point, chaotic confusion. Taking some of

the modern patented "improvements," so called, we find such utter ignorance of the foundation principles of the art displayed as to excite our astonishment. One proposes a card without a doffer! Another wants a card without workers and strippers! And still another has got his envious eye on the main cylinder, and takes out a patent for its abolition, proposing, instead, "an endless band of card clothing," so arranged as to take the wool from the feed-rolls to the doffer! These and similar devices seem to have been constructed or imagined on the hypothesis that carding can be performed more efficiently by reducing the carding surface.

Two devices, simply by way of contrast, may here be described, both recently patented. In one the main cylinders are displaced by a succession of 9 to 12 inch rollers, whose speed varies from 7 revolutions to 575. The first roller in the series, which takes the wool from the feed-rolls, revolves at a rate of 275 times per minute! About equal date with the above, another patent was granted for a carding machine without doffers, workers, or strippers; it

was all main cylinders, one set close up to another, and none less than 30 inches diameter. The fancy, however, was retained, but was *reduced* in size to 5 inches diameter.

We have doffers up to 40 and 50 inches diameter, main cylinders up to 70 inches; and we have them as small as 30, and the doffers down to 7 inches diameter. We have all sorts of speeds, from 40 turns of main cylinder to 200 or more. Hackle pins, combs, and reeds have all been tried and patented as substitutes for card wire; but how ridiculous this must be, when we reflect a moment that such things cannot be made practically to contain as many teeth per square inch as we now get easily in ordinary clothing, and therefore cannot have the same resisting effect; for in carding it is the collective resisting effect of the points, gained by their proximity and the nearness of the cylinders to each other, which enables us to get the best results. Amidst all these contradictory ideas we are almost driven to the conclusion that whatever principles there are in the carding machine must be either undis-

covered, or, if they have been discovered, are now lost. But I do not wish to be understood as implying that cards for all purposes should be of one stereotyped pattern; not at all; for the great variety of materials we now have to deal with furnishes ample reason for modifications in the carding engines. Yet this does not in any way interfere or affect the principles on which the process of carding is based. The present type of card, with its main cylinder, doffer, fancy, workers and strippers, is, no doubt, correct in principle; but the elements involved are not correctly applied in many cases, as we shall attempt to show.

A properly designed carding machine should have feed-rolls capable of holding the locks or tufts of wool well in contact with the first cylinder, or "taker-in," till the latter can divide and comb out the tufts, as far as possible, into separate fibres. To carry out this principle feed-rolls of small diameter are evidently best; then why do people continue to have such rolls made as much as 3 or more inches in diameter? Two inches are certainly as large as they

ought to be made, to perform their functions in the best manner; and, were it not for the difficulty of springing, they would be more efficient still if made smaller than 2 inches diameter. Again, a small taker-in will, for same reasons as apply to feed-rolls, open the locks of wool far better than a large one. Then for what reason are they often made 14 inches diameter, when it is plain a 5-inch cylinder will have a better effect? Precisely the same is true of "tumblers," surface sufficient to carry the material being all that is necessary. When we reflect how valuable a part of the card machine the tumbler is, how are we to account for the fact that many men dispense with them? Is not such an act equivalent to the cutting off a useful limb? That large doffers are found in practice to be better than small ones, for the reason that they present more surface to the action of the main cylinder, and therefore there is more carding done at the point of contact, and the wool is more evenly distributed on the surface of the doffer, making a more even sliver, seems so plain that any one might see it; yet we find

small doffers still being made and applied. It is gratifying to notice, however, that the idea of larger doffers is fast spreading in this country, and it is quite likely the next generation of carders will wonder how their fathers ever got along with doffers from 9 inches to 16 inches in diameter. We have seen cards lately built where the value of a large doffer was recognized, but rendered partly inoperative by increasing the size of the main cylinder in same ratio. Now, a moment's reflection ought to satisfy any one that the nearer two cylinders approach each other in their diameters the nearer you get to utilizing all the surface they are capable of; and the greater the disparity in their relative diameter the further you depart from all the surface you can get. Therefore, to complete my theory of a card machine, so far as respects the relative diameters of the parts, I only need add to what I have already said, that the doffer and the main cylinder ought both to be of one size, and the larger the size the more surface, provided they are both equally increased; and also more room is obtained for

workers of liberal diameters by using large main cylinders. Having a main cylinder, say 48 inches diameter, doffer 40 inches diameter, fancy 10 to 12 inches, or larger, workers 7 inches, and strippers $2\frac{1}{2}$ inches, would secure a distribution of carding surface well adapted to turn off good work. The doffer would be set low, and this machine would be run at such velocity as to suit the work, that is to say, very slow speed for short stock, and an increased velocity for longer and stronger materials.

In this country a set of cards consists of a first breaker, a second breaker, and a finisher, having a condenser attached. Each of these cards has but one main cylinder, generally 42 to 48 inches diameter, the doffers in the first and second card being mostly 16 to 20 inches diameter, with a few, recently constructed, of 25 inches. The fancies are mostly 9 inches, workers 7, and strippers $2\frac{1}{2}$ to 4 inches diameter. The finisher always contains 2 ring-doffers, mostly 9 inches diameter, with a few 12 inches.

The wool is transferred from first to second card in one of two ways, either by a "creel," or

by the "Apperley feed." The creel, in its various forms, is, however, almost universal for feeding the second card, and it is customary to set up before such card, one "drawing" per inch of width, that is to say, for a 48-inch card there would be set up in front of the second breaker, 48 spools or bobbins, containing the product of several hours' work of the first breaker. These are all drawn into one again at the exit of the second card, and similarly fed again to the finisher; but it is more common now to feed the latter card with the Apperley feed, which is continuous, and has a great advantage over the creel when applied to the finisher, because it distributes the wool across the card, which a creel cannot do.

We see, from this hasty sketch, that the second or intermediate card in this system fills a very important function, viz., that of a doubling machine. That is what it was originally designed for, and so it still remains. The carding surface could be more economically obtained, if that was the only object, by employing one double and one single card, and thereby saving

the cost of the feeding apparatus for the second card. The advantage gained by the use of the second or intermediate card, for doubling up the product of the first card, and thus (to the extent of such doubling) equalizing the irregularities before it enters the finisher, is so obvious as to be at once perceived by the merest tyro.

Passing now from the prevailing American plan to a consideration of the English system we are, at the outset, confronted with an entire difference, both in theory and practice. We will take, by way of comparison, a set of cards as now made in Yorkshire, England, where they still manage to get more poor material into yarn than they do in any other part of the world. The subjoined description is from the pen of a personal friend of the present writer, who is well known as a skilful carder in the district mentioned above, and the machines he describes are the common kind in use throughout Yorkshire. He says: "In examining the prevailing system here, and the extent of its utility when properly managed, — in other words, the prom-

inent features that indicate its efficiency for carding, — we will

Take a three-swifted 72-in. wide scribbler[1]—

With	one	38-in.	dia.	breast,	
"	four	36-in.	"	doffers,	
"	three	48-in.	"	swifts,	
And	three	8-in.	"	workers	over each swift,
	three	5-in.	"	strippers	
With	three	7-in.	"	angle strippers.	

Take also the carder of the following dimensions, viz., 5 ft. wide: —

With two swifts 48-in. dia.
" two doffers 36-in. "
" one breast 36-in. "
Strippers and workers same as in scribbler.
All fancies 14-in. diameter.

"For general work in the woollen trade, in the Leeds and Huddersfield districts, including also Dewsbury and Batley, the counts of the cards would range from 60 or 80 to 120 and 140, varying in crown from 6 or 8 to 12 and 13.

[1] The "scribbler" is the first card, and the "carder" is the finisher. They have but the two cards in a set. The "swifts" are the main cylinders.

"With such a set of machines the swifts, doffers, workers, and breasts would have upwards of 25,000,000 of teeth, or over 50,000,000 of points upon their surfaces. All these act as so many clutchers or resisters. The strippers and fancies contain close upon 6,000,000 more points, which act as carriers and springers. The resisting power of the swifts, doffers, and workers may be gathered from the following speeds of each: swifts revolving at the rate of 100 revolutions per minute, doffers revolving at the rate of 4 to 6 ditto, and the workers from 2 to 3. At these speeds the teeth on the swift will have a lineal velocity of about 14,000 in. per minute, the teeth on the doffers 500 ditto, and the workers about 50. Calculating that the teeth of every worker and doffer act as resisters for a space of half an inch at the point of contact with the swift, and taking the width of 72 inches, there would be a continuous resisting power of that of 250,000 points in a three-swifted scribbler which the material must pass, even if no lock, or nap, or fibre, returned over the worker or round the swift a second time.

This will give some idea of the carding power of a set of machines constructed on the present system."

Although at first sight it might appear that the efficient doubling, secured by the use of an intermediate card, is here dispensed with, yet, on further reflection, we perceive that, with their large doffers, and the number of them, together with their slow speed, with their system of carding, there is a great amount of one kind of doubling done, and that is a kind of doubling and of mixing of fibres which is of vital importance in carding their materials. Their finisher contains but one ring doffer instead of two, which, by its slow speed and large surface, allows of very "even" and regular distribution of the fibres, which, being all on one doffer, prevents any difference in the composition or dimensions of one thread from another.

To carry the material from the first breaker or "scribbler" to the finisher or "carder" the lap feed is mostly used, because it gives the most regular distribution attainable by any known

feeding device, and also gives a larger amount of doubling than can be otherwise got with two cards. See "Automatic Feeds" for further particulars. Sometimes they take all of the threads from this doffer off through a single set of rubs; but it is now more convenient to take half off through one set of rubs, and the balance through another set.

The writer has recently (October, 1880) seen many sets of such cards running in the district referred to, and his impressions gained on the spot led to the belief that such cards, especially for short materials, give every satisfaction. The work was even and regular, and the production fair, considering the amount of carding they deem necessary for such stock; about 400 lbs. per 10 hours of roping, spun to say 2 runs, being a fair average.

The reader ought to be able to form a tolerable idea (from the descriptions and contrasts given, first, of the principles involved in the process of carding, and, secondly, in the manner those principles are applied, both here and abroad) of the capabilities of his machines, and

where they may be improved. It is to be hoped these facts may lead carders to form correct ideas of what a carding machine should be, and may help, in some measure, to establish a theory of carding founded on the fundamental laws which govern it, instead of the chaotic notions, everywhere so common, and which have neither law nor reason to lean upon.

CHAPTER II.

THE CARDING PROCESS.

This term is employed to designate that entire process, beginning with the presentation of the locks of fibrous material in the feed-rolls of the first carding engine, and ending with the delivery of the finished work at the condenser, ready to be spun into yarn. Therefore this "process" covers the entire operations of a "set" of cards, however many parts such a set may consist of. One manufacturer employs a set having 2 main cylinders; another must have in his set 7 or more main cylinders. The last may contain 10 times the amount of carding surface, as compared with the first set; but the term "carding" applies all the same. Not to be deceived, however, by this broad application of the term, it is well to remark that it means a great deal more when applied to the second than to the

first case, so much so, in fact, that the first set could by no possibility be made to perform the carding operation in the thorough sense in which the carding is performed with the other.

We may tersely define *carding* as consisting of the following elements: —

1st. A thorough amalgamation of the component fibres.

2d. Their rearrangement in parallel form.

3d. Cleansing them from refuse matters, and

4th. Uniting and condensing the fibres into threads for spinning.

In other words, carding, whether done on few or many machines, or whether on large or small ones, is a separating, opening, straightening, cleansing, and mixing process; in its essential nature always the same, but as to degrees of excellence varying greatly.

To accomplish these objects in a speedy manner, with a minimum of loss, rotary surfaces, covered with teeth of varying density and thickness, are employed.

These surfaces differ both in circumferential

extent and velocity; in each case governed by their respective functions and the nature of the material acted upon. For the same or equivalent reasons these surfaces are fixed at varying distances apart, relative to each other; and it is a knowledge of all these facts and their proper adaptation, which enables one to practise the art of carding.

Sometimes these surfaces are flat, or partly circular, and sometimes partly rotative, intermittent, or stationary. The points with which they are covered require to be exceedingly *sharp*, in order to lay hold of the fibres with great readiness on the one hand, and also exceedingly *smooth*, in order to let them go with equal facility on the other hand. For similar reasons the teeth or points are deflected at suitable angles, tangential to the surfaces of said cylinders.

The carding machine for wool is expected to perform the work which, in cotton manufacturing, is done by the carding engine, — drawing, slubbing, and roving frames; a combination of machines which serve, by manifold

doublings and crossings, to equalize every inaccuracy; they also serve, by repeated drawings, to straighten out almost every fibre, and range them in the direction of their length in a most perfect manner. Nor does this cover the contrast between wool and cotton carding, for the fibre of cotton to begin with is quite straight, and needs but little carding to accomplish all that is desired; in fact, the carding of cotton is more a means of preparation for other machinery and processes than carding in the sense we understand it in wool.

The woollen card has an exceedingly difficult fibre to start with, which varies with every flock of sheep from whence it originated; there is no such thing as regularity or uniformity connected with it. There are long and short, thick and thin, greasy, burry, fleece-grown, scabby, and numberless other features, all differing in the degree or nature of the carding required, all needing some modification or another to reduce them into condition for spinning into yarn. Then there is the wonderful and almost endless variety of breeds of sheep, every one of which

has peculiarities involving some modification of the carding process. Add to these difficulties, which are wholly connected with the fibre itself, the mechanical problems involved in the efforts to make a set of cards do all the drawing and doubling that is in other trades done subsequently by costly and intricate machinery, and we see what is included in the term as applied to wool of "the carding process."

Between the carding engine and the loom in the woollen manufacture there is but one machine — the mule — and at most there can be but two processes of doubling: How different in the cotton manufacture, where the machines between the card and the loom are so numerous, and the doublings amount to thousands!

The manufacture of cotton is a purely mechanical one; the woollen manufacture can never be so. A cotton manufactory will go on day after day, for years, without material change or alteration in the machines or processes. A woollen manufactory, on the other hand, is changed in some respects for every batch of wool. In the latter case it is all change and modification,

requiring great forethought and great experience to, first of all, foresee the possibilities with a given lot of wool, to correctly judge its capabilities, and to know how to extract the best there is in it. Cotton in the raw state costs but a few cents per lb.; wool is dearer per lb. than 10 yards of the manufactured cotton cloth, and a yard of cloth made from ordinary wool is worth from 15 to 20 yards of cotton cloth.

We make these comparisons partly in answer to the query, "Why don't some one write a book on cotton-carding?" and also to show how much there is in wool-carding. The spinning of cotton is a far more important operation than its carding, and in all books, as well as such patents as have been taken out, connected with this process in cotton, we always find them styled "cotton spinning," the carding being looked upon as a subsidiary operation, secondary to spinning.

Woollen carding, then, is necessarily an intricate operation, dealing with a very delicate as well as a very costly raw material, and from this we see how important it becomes for those

who undertake to practise the art, to study well both the material and the mechanism they have to deal with. We see, also, what a field there is for improvement, for progress, and for emulation.

CHAPTER III.

PRACTICAL OPERATIONS.

TURNING OR TRUEING CYLINDERS.

It is of the first importance that all card cylinders should be absolutely true.

The cards should be on a solid floor, perfectly level, and parallel with the main line of shafting. Before commencing operations it is well to remember the following rule, which applies in all cases, and *must* be strictly observed, namely, that the point of contact of the turning tool with the cylinder should be on a level with, or slightly above, the centre of such cylinder. In the case of a main cylinder it becomes necessary to elevate the tool considerably above the frame of the card, and for this purpose blocks of wood should be provided, of such thickness as will, when added to the depth of the turning-rest, bring the tool on a level with the centre of the cylinder. The

doffer is removed, and one of these blocks is placed on each side of the frame close to the arches, and the "rest" is placed thereon, the whole being held in position with a carpenter's hand-screw at each end, opened sufficiently wide to admit the "rest," blocks, and flange of the card-frame, or bolts may be used to attach the turning-rest temporarily to the card-frame. Observe that the "rest" is exactly level and parallel with the cylinder, then tighten down the hand-screws, and put on the belt. Push the tool to one side, and hold a thin piece of wood, grain end, to the cylinder, while the same revolves towards you; this will remove any foreign substance from the wood, which otherwise would injure the tool. It is best to take off several successive thin shavings than to attempt too thick a shaving at one operation. Push the tool along by hand steadily and uniformly, applying sufficient downward pressure to keep the tool close to the "rest," and keep the V or slides well oiled and clean.

It is not advisable to use the screw and crank, sometimes provided, for moving the

tool along, and having a heavy weight suspended from the tool-holder ; it is better to guide it with a steady hand, moving as the eye dictates, firmly and uniformly. With a sharp tool, managed and adjusted as described, a better job will result than by any other plan the writer knows of.

If sand-paper is used, proceed with caution, or the truth of the cylinder will be destroyed. The sheet of sand-paper should be bent around a block of wood, and passed from side to side once or twice, to insure regularity.

Some carders use the emery-grinder for trueing their cylinders instead of the turning-tool. This is bad practice. It leaves the cylinder rough, in no fit condition to receive the clothing, and spoils the emery-grinder. Card clothing cannot be uniformly stretched on a rough wooden surface. The surface should be smooth and glossy, clear cut with a sharp tool.

In turning all the smaller cylinders the same general rules apply. They may be turned in the grinder frame, a couple of iron brackets

being attached at each end of one side of said frame, and at such a height as to bring the tool on a level with the centre of the cylinder, when the turning-rest is placed on the brackets, and the tool is in position.

Always see that the shaft of the grinder, the turning-rest, and the article being turned, are exactly level and parallel with each other. To test the truth of the "rest," and parallelism of the same with the article operated upon, two cylinders (as workers) may be turned carefully true, and arranged one exactly over the centre of the other, with strips of thin paper between them at each end and in the middle; if these strips offer equal resistance on being pulled it proves everything correct. If, however, the middle strip be loose, while the end strips remain tight, or *vice versa*, it is evidence that one of two things is wrong; either that the "rest" is untrue, or more probably that the cylinder was not on the same horizontal plane as the turning rest while being turned. It is quite easy with a perfectly true "rest" to turn an untrue cylinder, if this important matter is over-

looked, the perfect parallelism of one with the other. Beeswax slightly warmed is the best thing to stop up small knotholes, if such there are, so that none of the teeth shall sink below their proper level after the clothing is put on.

It is the duty of every carder, both to himself and to his employer, to insist on having his grinding-frame and all its belongings of the most improved kind, fixed in the most perfect manner, so that there shall be no vibration or lost motion anywhere. Without these precautions it will be useless to expect a good, true job to be done; and it is a very serious matter when we reflect that one grinding-frame and one turning arrangement have to be used on many cylinders, all of which will be out of true, or otherwise imperfect, if the instruments provided are themselves incorrect. The efficiency of several sets of cards may be greatly injured by carelessness at this point. The grinding-frame and turning-rest are instruments of precision, and they *must* be so perfectly fixed as to be implicitly relied on.

Be *sure* they are right before going ahead.

STRETCHING ON THE CLOTHING.

For the sake of simplicity we will arrange this subject under three general heads: —

1st. Clothing with sheets.

2d. Clothing with filleting.

3d. Clothing with rings.

1st. Clothing with Sheets.

As the main cylinder was first considered in the remarks on turning, we will clothe it first, allowing the turning-rest to remain in the position it occupied in turning off the cylinder.

Lift the tool from the "rest," and with the cylinder still revolving run a pencil mark around $\frac{3}{4}$ inch from each end; on one of these lines score off, with a pair of dividers, as many equal divisions as there are sheets of card clothing, making a dot at each intersection. Cut a flat point on a lead pencil, tie it to a thin lath long enough to reach across the bed of the turning-rest; then turn the cylinder towards you until one of the dots comes opposite the pencil point, holding the lath at right angles across the

"rest" (which answers the purpose of a straight edge) and the pencil in contact with the wood; now run across to the other side, leaving a mark which is exactly parallel to the centre of the main cylinder. Proceed the same with the remainder, then remove the "rest," and the cylinder is ready for the clothing. From the foregoing it will be seen that we save time, and also do the work of scoring off the cylinder very accurately, by leaving the turning-rest undisturbed, and thereby using it, first, to turn off the cylinder with, and, second, as a straight edge, by simply removing the tool or pushing it to one side, out of the way.

STICKING THE TACKS.

It is best to stick the tacks in the sheets before commencing to nail. For this purpose procure a board long enough to extend across the frame of the card and 8 or 10 inches wide; divide this into equal spaces across the width of the board, say $\frac{7}{8}$ inch apart, with dividers and try-square. The sheets are laid one at a time on this board, some distance from the lower

edge, so that the lines can be seen, and they are previously ruled, as follows: in the centre of the narrow or upper edge of the leather a line is run with the point of dividers or scratch-awl; for the lower or broad edge get a lath $\frac{1}{4}$ inch thick, the length of the sheet, and place it on edge against the teeth, and on the other side scratch a line, as directed for the top edge. The tacks are set along these lines, as far apart as the lines on the board. A boy, with a light hammer, can now stick the tacks while you are engaged in nailing them into the cylinder; and he must be cautioned against driving the points *through* the leather, as all they need is sufficient hold to prevent their dropping out. As fast as each sheet is completed they can be laid one on top of the other until required.

The above-described plan is considerably ahead of the old way of using a punch, and putting the tacks in as the nailing proceeds, and it saves the valuable time of the carder, or other person employed to do the nailing, by substituting the cheaper labor of a boy. The job will also be better done, and neater, as the tacks

will be perfectly equidistant all around, giving a mechanical finish to the work not otherwise attainable.

For a cylinder made of "lags" use 12-oz. tacks, and for a "block" or segment cylinder 10-oz. will be found large enough.

STRETCHING THE SHEETS.

The best plan for stretching sheets is as follows: Have two wooden pulleys made, each $1\frac{1}{2}$ inches across the face, 16 inches and 4 inches respectively in diameter, fastened securely together, with a hole full $1\frac{1}{2}$ inches diameter through the centre of both. A rod of $1\frac{1}{2}$ inches round iron (an old feed-roll will do) is now placed across the frame of the card, and on this the double pulley should slide freely. The hand-screws previously used to hold the rest when turning may be employed to secure each end of the roll or rod at a distance from the main cylinder of one inch between it and the larger pulley. Nail the upper edge of a sheet to one of the lines on the cylinder, and to the lower edge place the clamps, turning the cyl-

inder to a convenient height for nailing. Now put one end of a piece of $1\frac{1}{2}$-inch belting through the loop in the clamps and rivet fast. Measure the length necessary to reach down and once around the small pulley; fasten the end to the face of small pulley with wood screws. Another piece of belting is now fixed, one end to the face of large pulley, with screws, and of such length as to form a loop for the foot, so as to not touch the floor when stretching. A stirrup may be riveted on instead of a loop. It is now ready for use, and, if well made, will prove a source of pleasure whenever you are called upon to use it. To hold the cylinder rigidly in position while stretching, a bar of iron may be used, about 5 feet long, placed inside the frame, one end on the floor and the other against one of the lag-bolts in the cylinder. By raising or depressing, or changing from one bolt to another, any convenient position can be given the cylinder. Iron "dogs" projecting from the frame of the card into the ends of the cylinder lags should not be used; they mar the ends, scratch off the paint, and spoil the appear-

ance of the card. No good workman will do this.

The ends of the sheets should be stretched first, following up the intermediate space from the end last nailed.

You can, with the appliance described, put on any degree of pressure easily, and a rule can here be laid down applicable to all leather card clothing, namely, that if you take all stretch out of the leather at the first nailing of the sheets, etc., you will not have the annoyance of a second stretching after the lapse of a few weeks or months; the clothing will keep sufficiently tight until worn out. If English calf-skin clothing is used it will not need the amount of stretching desirable with American clothing; if it is simply strained tight it will answer.

Tack-hammers as usually furnished to mills are of no account. A good one should have a head 10 inches long, bent to an arc of a circle of 12 inches radius, and should weigh about 12 ounces. The handle should be light and about 12 inches long, covered with leather, and the

ends of the hammer should be 1 inch wide, $\frac{1}{4}$ inch thick, or one end may be thinner and narrower. A hammer of this kind will reach over the clamps without the handle continually striking them; at first it may seem awkward, but it needs only to be used to become appreciated.

After the lower edge of the sheet is nailed, trim off the leather neatly to the pencil mark in the cylinder with a sharp knife, and then you are ready for the next sheet.

Nailing the last sheets is more difficult, there being no bearing for the clamps. A block of wood 3 inches long by 1 inch square can be placed in the space between first and second sheets, serving as a bearing for the clamps, thus protecting the wire. After all the sheets are on, the ends can be drawn out square and a tack put in each; then trim off any surplus leather and get a strip of old filleting, $\frac{1}{2}$ or $\frac{3}{4}$ inch wide, run it around the ends close up to the wire, for the purpose of supporting the same and giving a more finished appearance to the job. Drive a tack here and there to hold it in position, replace all broken tacks with good

ones, raise up crooked or crushed teeth, and the cylinder is ready for the grinder.

2d. Clothing with Filleting.

Make a frame 6 feet long, $3\frac{1}{2}$ feet high, and as wide as the distance between journals of workers, etc., to be clothed. The frame is composed of 1-inch boards nailed on to corner posts, say 2×4 square, and braced together. On the upper edge of each side, at a proper distance from the end of frame, saw in a notch large enough to receive the journals of the largest article to be clothed. At the other end of the frame saw two more notches on the upper edges of the same side-boards. These are to receive a doffer, or other large cylinder, for the purpose of a stretcher. On one end of the latter, outside the frame, a pulley is fixed on the shaft over which a strap is placed, one end secured to the floor or side of frame and the other arranged to receive weights, the whole answering the purpose of a brake to the stretching cylinder. On one end of the stretching cylinder itself is tacked a strap long enough to

reach to the article being clothed. To the loose end of this strap is fixed a small clamp, made as follows: take two pieces of $\frac{1}{4}$-inch flat iron, $1\frac{1}{2}$ inches wide, one piece 3 inches, and the other $3\frac{3}{8}$ inches long; the longer piece is bent downward $\frac{3}{8}$ inch from the end, and at right angles, and forms a lip over the end of the shorter piece, when both are placed together similar to card-clamps. Through both these pieces, in the centre, a $\frac{1}{4}$-inch hole is drilled to receive a thumb-screw or small bolt. Three or four smaller holes are now drilled in both at the opposite end to the lip, between which the end of the stretching strap is placed and the whole riveted together.

To clothe a worker, place it the right way around in the notches of the frame opposite the stretching cylinder, and open out the clothing on the floor carefully; select the proper end, attach it with a tack, and wind the clothing on the worker loosely, but close, until you arrive at the other end, which is now trimmed off square, an inch or so of bare leather being left; this is placed between the clamps, which are tightened down

upon it. Now turn the stretching cylinder from you so as to transfer the clothing from the worker on to the latter. It now lays in proper position to be stretched, and will need very little straining to cause it to assume its proper position on the worker with regularity and evenness. A pair of dividers is now taken, and the circumference of the worker divided into as many equal parts as there are crowns or rows of teeth in the fillet; the dividers are fixed with an opening equal to one of these divisions. Pull a few teeth from the first row, measure the second and each succeeding row with the dividers and pull out to the point indicated; now trim off the surplus leather $\frac{1}{4}$ inch from the corners of each row of teeth, and nail the end to its place on the worker; turn the stretcher back to take up slack, and put on the brake. To turn the worker against the strain, a windlass can be made of two pieces of $1\frac{1}{2} \times 3$ inch ash or oak, $2\frac{1}{2}$ feet long, halved together in the middle, and worked down round towards each end to form handles. After securing the pieces together with common wood-screws, or small

bolts, a $1\frac{1}{2}$-inch hole may be bored through the centre. On the end of the worker shaft opposite to where you commence the clothing, a pulley is fastened a couple of inches from the end; on to this and against the pulley the windlass is now placed, and at proper places, in opposite arms, holes are bored to receive $\frac{3}{8}$-inch bolts, bent in the form of a hook, long enough to pass through the windlass and hook on to the arms of the pulley; nuts are screwed on, thus fixing the windlass to the pulley and worker, An iron windlass may, of course, be used instead of the above; but there is the difficulty about its not fitting the different sizes of shafts of the cylinders to be clothed, for all of which the wooden arrangement answers by using a pulley to fit the shaft. Iron clanks are simpler and more commonly used, but they have the disadvantage that the force has to be applied at one point only, and therefore cannot be turned with as much regularity as the windlass.

A boy may now turn slowly and steadily, while you guide on the clothing. I say guide, because I don't believe it proper, nor would ad-

vise others, to jam or punch the clothing into place by pounding its edge with anything; it cramps the teeth, upsets the leather, and is an unworkmanlike way of doing the job. It is far better to give the clothing a quarter twist through your hand, guiding each successive round against its fellow, without leaving gaps or allowing one edge to surmount the other. Make the boy turn steadily, that is the main thing; jerking will be apt to break the clothing or unduly stretch it in some places, while others are not stretched. If you want the clothing to remain in good order, and never give you any future trouble, be sure and put it on under *even* tension. When it is all on, the end can be divided, etc., as before instructed, tacked fast, cut off, and trimmed.

In using English cloth, whether as sheets or filleting, this stretching must be dispensed with; it simply needs to be put on just tight, no more, and any stretching will spoil it.

In taking off the windlass it is only necessary to loosen the set screw in the pulley, taking off both together.

In clothing large doffers with fillet I have adopted the following plan, which obviates moving the doffer: it is put in its proper place on the card, and a roller 6 or 7 inches in diameter is fixed some 3 inches from the floor, so as not to turn, at a distance from the doffer such as to leave standing room, and the clothing is passed once around the roller. Owing to the large diameter, it would be impossible to turn a 32-inch doffer were the windlass attached directly to its shaft, unless several persons were employed to do it.

To make it perfectly easy put the large gear wheel on doffer end, also the stud and pinion, and pulley which operates the same. On to this pulley the windlass is fixed, accomplishing two important points, viz., a slow and exceedingly steady motion with any amount of pressure. A boy stationed behind the fixed roller will keep enough strain on the clothing, besides feeding it regularly as needed. I have often clothed those big doffers (in a new card) before the main cylinder was clothed, by using the latter for a stretcher, putting a strap and weights

over the large stripper pulley. This saves the trouble of fixing a separate cylinder on the floor; but, of course, is not applicable except when the clothing is off the main cylinder. The doffer is lifted out on trusses when clothed, until the main cylinder is finished, when the latter is used as a stretcher; but, if clothed with the roller, it is not necessary to move it.

3d. Clothing Ring Doffers.

Procure a box, turn it upside down, and bore a hole the size of the doffer shaft through the bottom, which is for the present on top. The doffer is put on end, upright, with the shaft through the hole. To help the rings on, a cone of wood is used, 6 inches or so thick, the same diameter as the doffer at the bottom and about ½ inch less in diameter on top. Through the centre a hole is made, large enough to slip easily on the upper shaft so as to rest on the doffer end. The rings are slipped over the small part of the cone and pushed down about an inch over the doffer.

Now procure a square board about 1 inch

thick and about 4 inches larger than the diameter of the doffer. In the centre a hole is made $\frac{1}{16}$ inch larger than the doffer; this is now put over the cone and lowered on to the ring, bearing only on the leather or other foundation. Two persons, one on each side, now press the board downwards steadily, carrying the ring beneath it to the desired place. After proceeding in this manner with each ring the doffer may be lifted into the grinder, and the other one, if there are two, proceeded with in like manner. The rings will at this stage be at varying distances apart, and before they can be arranged a gauge must be provided, which can be made as follows: get a stick of pine $1\frac{1}{2}$ inches square, planed off true, and long enough to extend across the card-frame. This is placed against the main cylinder and a mark made on it at each end corresponding to the length of the cylinder. Inside of each of these marks others are made, even with the card wire of the shortest sheet, with which the cylinder is clothed.

Now remove the gauge and make another

mark $\frac{1}{8}$ inch inside of each of the last ones named, and with a try-square rule each of the marks across the face of the stick with a flat-pointed lead-pencil. The inner lines represent the position for the outer edges of the teeth of the end rings on top and bottom doffers.

The distance between these inside lines must now be divided carefully into as many equal parts as half the number of rings to be used on both doffers. A pair of sharp-pointed dividers, with an adjustment screw, should be employed. Each division should now be ruled across with the pencil and try-square perfectly distinct. The dividers are now set to the width of the top rings, and put one leg to each mark previously made, making a dot with the other leg; these dots are now intersected with pencil lines as before. The stick is thus laid off into alternate wide and narrow divisions, representing the width of wire on top and bottom rings, and their relative positions. The outside ring on the top doffer should be on the end opposite the stripper belt, in all cases, and this must now be borne in mind or the rings will be wrong.

If only one doffer is used, then gauging of this kind is not required. Supposing, however, there are two doffers, and the cards are 48 inches wide, then the first set of divisions will number 24, and be about 2 inches apart. Then when each of these is set off for the top rings, there will be added 24 spaces more, making 48, which is the whole number of rings for both doffers, and thus laid out the stick will answer for both.

The doffer being in the grinder with the teeth pointing from you, and a belt on ready, arrange your gauge-stick in front about $\frac{1}{8}$ inch from the face of the doffer, and secure firmly in this position.

Each end of the doffer is now fixed, by means of the movable collars, at an equal distance from the outside marks on the stick, or, in the absence of movable collars, the stick may be moved as desired.

All being ready the doffer can be started up, and should run towards you at good speed; it will be easy in this manner to get the rings perfectly true. To guide them as they revolve

nothing is better than a piece of pine shaved down rather thin at one end, so as to enter between the leather of the rings, which, by gentle pressure against their edges, can be slid in true circles into exact position as indicated by the lines on the gauge-stick, which answers also as a rest for your thin guiding-piece. The other doffer is treated the same, being particular to notice that you get it right at the start. When both are done lay them side by side across the card-frame, and gently push them close together, when, if correct, the narrow rings will interlock perfectly with the others, and they will only do this when the ends of the two doffers are square with each other.

Strips of filleting, as free from grease as possible, are now prepared the right width to enter between the leather part of rings. Those strips are now glued in, the ends butting together, or (if you want to go to the trouble) overlapping a little. Another lot of strips, wide enough to fill the spaces between the wires of the rings, are now provided, and these should be long enough to overlap an inch, and carefully skived off so as

to lay smooth when glued together. In cutting both the narrow and wide strips be careful and not get them too wide, or the rings will be forced out of true. Short, copper tacks are often used instead of glue, on iron doffers; but the plan is not so good or neat.

Another plan, invented by the author so far as he knows, and which answers every purpose of keeping the rings in place, besides the double advantage of cheapness and quickness, may be described as follows: having gauged the rings as described, and with the doffer revolving from you, provide a bobbin of cotton yarn about No. 20. Holding it in the left hand, so as to freely run off nose of bobbin, with the thread passing between thumb and fingers of right hand, let the end touch the outside ring, when it will instantly cling to the teeth. Now guide the thread neatly back and forth in the space between leathers of adjacent rings, winding one layer over another until of same thickness as leather of ring; then quickly cross over to next space, and so on continuously to the end. The whole operation will not take as long as to cut

the leather strips in the old way, and costs about one-tenth as much. When done stop the doffer, and with a small brush and thin glue solution saturate the cotton, having first cut the crossings from one space to another, and tied the ends together. The grinding may be at once commenced, and the packing will dry as the grinding proceeds. This makes a solid, compact filling, with no danger of displacing the rings. If thought desirable, wide strips of leather may now be put between the wire of rings and tacked with small copper tacks.

If the "Apperley" feed is used, or the lap, or "Blamire" or "Scotch" feed, or any other self-feed, on the finisher card, then it is necessary to make an extra thread on each side, called a "waste" thread, and in that case the gauge stick will have to be divided with two divisions more than as directed. (See further on this point under head of "Automatic Feeds.")

CARD-GRINDING.

There cannot be a reasonable doubt but a very large percentage of card clothing is destroyed, or rendered practically useless, by a too free or rough usage of the emery-grinder. Especially is this true in American mills, and one has only to ask himself whether the clothing he sees regularly thrown away, or burnt up as useless, has become so by contact with the wool in its legitimate working, to be convinced that other causes have been at work to destroy it. Much too often it has met its fate prematurely from one cause or another, but if we were to name the most prolific cause we should not hesitate to charge it to careless use of the emery grinder.

To one who has not studied the matter it will, no doubt, seem surprising how little grinding is really necessary when cards are properly fixed and have reasonable care bestowed upon them. The plan we shall recommend will be found to differ materially from that generally followed, and as this book aims

to be cosmopolitan in all things, — speaking of that which is good, wherever found, and describing that which is bad even if found in this country, — we shall set up as an example for American carders to follow, in the matter of card-grinding, his contemporary on the other side of the Atlantic, who certainly has the right to be held up as a monitor worthy of emulation, if we take into account his longer experience; or we can find a yet stronger reason in the fact that he still continues to outdo us in the economies of manufacturing; and if the reader does not feel disposed to allow this we can assure him it is because he is not well informed.

Beginning with a main cylinder we may say, that, barring accidents, it ought not to require grinding, in the full sense of the term, after it has once been put into shape when new; neither should the doffer, and it is optional whether the workers shall ever be ground more than once. As for the strippers they need only to be made quite smooth in the first place, and after that need not again be ground

for years. The fancy, once smooth, is all right so long as it endures. The tumbler, once having a good point, needs only to be kept smooth afterwards, and the "licker," or taker-in, ought to be wholly of metal, not therefore requiring to be ground.

Now, the unpractised reader, who has always been taught to grind and grind by rote, so many times a month, or year, each piece so long a time, by established rule or whimsical notion, may be pardoned for doubting that the cylinders of a carding engine can be made to keep themselves sharp enough for an indefinite period; yet it is not only possible, but extensively practised.

There are two kinds of points which can be had on a card tooth. There is a point which can be got on to a tooth with emery; but there is another kind infinitely more valuable as a carding point, and that is such a one as can be *worn* on. Such a point is round, in the form of a needle, and it can never be got on with emery, however applied. It is sharp enough for the work, and, better than all, it is absolutely smooth.

I maintain that of the two a smooth point is of greater value than one merely sharp. An emery roller, no matter how made, the best in the world, cannot produce a point which is not more or less rough, and therefore so much and so far undesirable. Still I must not be understood as implying that I can get along without such a point as a grinding roller or disc can give, — not so; but I do say that such a point is valuable only as a foundation, a beginning.

Given as good a point as can be obtained on the newly covered main cylinder, we will, barring accidents, and having the wool or other material free from refuse and properly prepared, using only reasonable care and diligence, run that cylinder until worn out without putting a grinding roller again to it. We will make the fancy keep that cylinder sharp and smooth, so that its condition shall improve from day to day, and it shall have the same effect on the fancy as has been exercised by the latter on the cylinder.

We will keep the doffer sharp by employing a "dicky" or "tickler," a thing no doffer should

be without, and which is more fully explained under the head of "Doffer."

The workers may be kept in excellent condition indefinitely, by setting the strippers against them, not too hard, but sufficient to *maintain* the point against the wear of the fibres. The reader will no doubt say, "But how about the strippers?" and our reply is, they will lose their sharp, keen edge, so much admired by novices, and in lieu thereof they will become very smooth, and obtain a sort of point quite as effective (set as close as we describe) in stripping the worker, and more effective in allowing the stripper to deliver its load.

In the article on turning I have said that the first requisite is to have all card-grinders perfectly true, which, of course, they must be to carry out the above plan. The practicability of the plan is attested to by some thousands of sets of cards in the Yorkshire district in England, which are never run any other way, and are rarely ground more than once in 5 years.

Nor does this apply to one particular kind of

stock; the fact is, it is universal and need not be longer dilated upon.

One of the best devices ever got up for treating card clothing is the so-called "fiddle," consisting of a piece of emery-covered cloth, stretched between two end pieces and held together by a curved handle. This tool is extensively used in the district referred to, as it answers every purpose of smoothing the points and also shaking out much fine dirt from amongst the teeth. Every week or two this ought to be run over the cylinders for a few minutes, and that is all they require.

In the whole practice of carding there is no single thing of more importance than the grinding of the points. The carder should always give this his personal attention, and never leave it in the care of a subordinate. It is only by long experience and careful study that any one is competent to practise this peculiar process, which requires on the part of the workman a full development of at least three out of the five senses to become an adept at it: he must have a sensitive touch, in order to feel the gradations through

which the points pass from the commencement to the finish of the operation ; the sharpest eye, to discover irregularities in the minute teeth and in the various adjustments ; the quickest ear, instantly receiving the smallest variations of sound in the grinding cylinder, in order to so adjust it that the whole of the points shall be ground alike ; and in addition he must have excellent judgment, to know when to grind and when to stop.

The most common error is too much grinding ; it is better to stop short of the mark than overstep it in the least. Fine emery should never be used, as it makes a surface too flat, grinding the top of the tooth only, producing a point more like a chisel than a needle.

A needle-point is what must be aimed at, and anything that will assist in producing such a point should be eagerly taken advantage of. The traverse grinder is the only tool that at all enables us to approach this point. There are two forms of this tool in use, one attached to a stationary frame, operated by a screw underneath, receiving a forward and reverse

motion from an open and cross belt at the end, alternately giving motion to the screw. This motion causes the emery-wheel to slide to and fro on a heavy slotted shaft, the hub carrying a feather, which gives the circular motion to the pulley. The other form is known as the "Hardy," or "Biddeford" grinder, consisting of a hollow shell, on which the grinder pulley slides, being moved back and forth by means of a set screw, passing through the hub of pulley, through a slot in the hollow shell, and, by the intervention of a "dog" of suitable shape, entering into the threads of an endless screw inside the shell before mentioned. Both shell and screw revolve in the same direction, but at varying velocities, causing the grinder to revolve, and also travel from side to side. This machine is used mostly to grind main cylinders, and sometimes put in a suitable frame for smaller articles. The maker builds one form especially for smaller cylinders, which is so arranged as to grind several articles at the same time. But the grinder first mentioned is most useful for small cylinders, where cards of

various widths are in use, as the length of traverse can be regulated at will; but with the shell-grinder this is impossible. The former, however, is altogether too clumsy to be used on main cylinders.

A recently invented grinder is now being introduced and known as "Roy's grinder." In principle it is the same as Hardy's, as the latter is of Horsefall's, who was, we believe the originator of the traverse grinder, or at any rate the original manufacturer. But Roy's differs in this, that instead of an endless screw, enclosed within a tube, he employs an endless chain. The only practical advantage is that the wheel can be made on this plan to traverse from side to side faster without getting out of order than with the endless screw. This is an advantage within certain limits.

The grinder, of whatever type, should be truly covered with a coarse grade of emery, the grains of which will enter to some extent between the teeth, thus grinding off the sides as well as the top by the back-and-forth motion of the emery-wheel. It must be perfectly level,

and steady running; this is doubly important in this connection, for on it depend the truth and exactitude of all your cylinders. Each separate article must also be levelled before commencing operations, for it is a fact, that if both grinder and article being ground are not exactly parallel with each other (and there is no way of knowing this only by levelling them both), the article will be ground out of true, and all previous care in turning will have been useless.

When any cylinder is levelled it is important that it should rest on its bearings *only*, and the same when undergoing the grinding operation.

There has been a great deal said both for and against "facing" cards, or, in other words, grinding against the teeth, or the wrong way, before commencing the final grinding. I unhesitatingly take sides with those in favor of facing; first, because with a new card the teeth are irregular, and it is among the impossibilities to produce equal points on each tooth, when they are irregular at the commencement; second, it is equally important with a card that has been in use and which may be very slightly out of

true, but not sufficient to justify taking off the clothing; and, thirdly, when the clothing is worn unequally. Under these conditions it is evident that all irregularities must first be removed before it can be hoped to give each tooth the same amount of point. Suppose the final grinding to be at once begun without previous back grinding or facing; those parts that are highest reach the desired point first, and if operations cease at this stage those parts that are low have no point; and if you continue until the latter are in shape, the former will have become hooked; for it is well known that card wire, if overground in the smallest degree, results in fine hooks being formed by the points turning under, rendering the card in worse shape to fulfil its office than if put to work without grinding.

Considerable care is necessary in facing, or the delicate wire will be strained backwards. Set the article at first very lightly, the object being not to grind the entire surface, but to reduce high places to a common level. After the burr or rough edge has worn off it may be set a

little closer, and so left until the whole surface presents a uniform smooth appearance. The article can now be reversed; in other words, turned end for end, with the teeth pointing in the proper direction for final grinding.

The facing will have produced a sort of edge on the back of the teeth, therefore commence cautiously until this roughness has disappeared, or the teeth will be forced forward by the grinder; once smooth, the danger is passed, providing, however, the grinding is not forced. Go slowly, setting a little closer occasionally, keeping both ends of the cylinder alike by careful listening at each end alternately, until the point appears perfect. I would impress on the carder the caution not to set on too hard, for this does not accelerate the grinding, as commonly supposed. It is one of the easiest things in the world to injure, if not ruin, your cards through incaution in this particular, and, I may add, one of the hardest things not to do it. I believe it to be a fact that more card clothing has been ruined by injudicious grinding than by all other causes combined.

When the cylinder has become very smooth, having a velvety feeling and a fair point, — *stop*. If undecided about its being as sharp as you can make it — stop. I have seen so many who have gone a step or two too far in this matter, and thereby had infinite trouble, which they could not account for, that I should say always stop soon enough, bearing in mind that perfect truth and smoothness are most of all important. I consider the grinder as chiefly a "trueing" device; a means of bringing each tooth to an equal working-point, by first getting them all to the same length and into the same condition.

It is the best plan to grind main cylinder and doffer at the same time, without removing the latter from its bearings on the card frame.

Hardy's or Roy's shell-grinder is the best tool in use for this purpose. It can be placed on the fancy arms (the boxes of the latter being removed) and bolted down firmly. Be sure to level it first of all, setting it low enough to reach the doffer as well as main cylinder. The third stripper from the feed-rolls, with a pulley on

each outside end, will run the grinder, one pulley for the screw, the other for the shell, with a belt from the stripper inside to large stripper pulley on main cylinder shaft. The doffer can be operated at the same speed and in the same direction as the main cylinder, by means of a belt from either end of the latter to the former, whichever is most convenient. Before commencing set the doffer some distance from main cylinder, so as to give room for adjustment as the grinding proceeds. Be sure that each of the several parts are level; bestow great care on the doffer, for it requires the finest point and smoothest surface attainable. In this relation the main cylinder is secondary in importance.

Strippers are difficult to grind on account of their small circumference, and unless plenty of time is taken, proceeding very lightly, the teeth will become badly bent out of shape. This is especially the case when the clothing is new and the teeth stiff in the leather.

Workers need both point and smoothness, and come next to doffers in regard to the care-

ful treatment demanded during the operation of grinding. Their functions are identical with those of doffers, and should, like the latter, have a finer point than main cylinder, so as to readily seize the wool, and smoothness sufficient to readily part with it.

Ring doffers require gentle treatment, as only half their surfaces are covered with teeth. A little well worn and fine sand-paper is good to finally smoothen them off with when grinding is completed. They must be *smooth*, or uneven slubbing will inevitably be the result.

Before grinding any article, either new or old, it is best to examine the cylinder, and all teeth that are crooked or below the surface should be raised. Have every point up to its work; each one is there for a purpose, and that purpose will be the better fulfilled by bringing them all up to duty.

Since the foregoing was written for the first edition of this book the writer, by many experiments, has become more than ever convinced that smoothness rather than sharpness is most essential. It may be accepted as a safe rule

that, practically, smoothness is of first importance, just coming to a point — no more; that it is folly attempting to grind to an exceedingly sharp point, as it is beyond our present faculties to accomplish the desideratum of a perfect needle-point, without either producing a hook or burr on said points, or leaving them in such shape that they very soon become rough or hooked, through the nature of the work they have to perform.

There is no means of telling except by the feel when the point is right, and the sense of touch can make no allowance for any excess of grinding *after a point* has been once attained. The writer has used a large magnifying-glass in some of his experiments, and has found that the moment a sufficient amount of metal has been removed from the back and sides of the tooth, or teeth, to just bring the front to a point, a process at once sets in that rapidly spoils the point so attained, namely, the emery begins to form a burr or hook on account of the slight resistance offered at the extreme top and point of the teeth. Always be on the safe side and

stop, as before said, short of the mark rather than risk overdoing it.

It is altogether different from the foregoing when the ultimate point is worn on by friction of the wire teeth against and amongst each other, as, for instance, such a point as the fancy can be made to produce on the main cylinder, or such as can be produced on a doffer by a "tickler." A point so produced is only spoiled by coming in contact with an emery-roller, because it is as smooth and highly polished as the point of the finest needle, and the emery only makes it rough and furrowed.

Every grinding frame should have a strong revolving brush, to which the cylinder can be applied after it is ground, thereby cleaning out the wire dust, which should be drawn off by a fan underneath. All the English grinders are now so made, and notably those of Dronsfield, of Oldham, who has for many years been engaged in perfecting the tools used in the grinding and clothing of cards.

In Europe there are but few traverse-grinders in use, the emery-roller, covered as it is by

them in excellent form by specialists, who make a business of it, being well-nigh universally used. Such a roller is often as large as 16 inches diameter, being no longer a roller but a cylinder, and it is made to traverse 2 or 3 inches. The execution of one of these grinders is very rapid, and when the surface is evenly covered it does a satisfactory job in about one-third the time that a traverse-grinder would require to produce the same point. For ordinary work in this country I fail to see any great advantage in having the grinding-cylinder larger than 12 inches diameter. The small ones usually met with, of from 4 to 6 or 8 inches diameter, I consider injurious to the card clothing.

SETTING OR ADJUSTING CARDS.

This, although of importance in connection with other branches of the art, does not begin to be so momentous as is often supposed. There is no portion of a carding machine more difficult to properly adjust than feed-rolls in connection with leader-in and tumbler; yet how often this vital point is slighted, and by many

carders who, with elaborate gauges, waste time in setting other parts to the smallest imaginable fraction of an inch!

Before attempting to "set" the card, put on all the belts, including the driving-belt; otherwise you may find that the strain occasioned by the belts will disarrange your adjustments, and injure the points of the card clothing. No rule can be laid down in regard to the proper distances apart of the various cylinders, for those distances vary according to the stock in hand. As a general thing the finer or shorter the stock the more reduced these spaces should be, longer and coarser grades requiring larger spaces, etc. Where one set of cards has to be changed from one grade to another it is not necessary (unless there is very considerable difference) to alter the whole card, but merely the workers and doffers. The latter should, in any case, be nearest to main cylinder.

Cards should be set progressively, commencing at the first worker on the first breaker, and gradually bringing the cylinders closer together, finishing at the ring doffers. The second

breaker doffer should, for instance, divide the difference between first breaker and finisher doffers.

It is not of importance to set the strippers progressively, but only such parts as literally accomplish the carding, as workers, doffers, etc.

Strippers in their relation to the workers may be set all alike, as close as possible, to thoroughly clear the last mentioned. On first breaker they may be set a shade farther off, and on finisher closer to the main cylinders than on second breakers.

It is best to use gauges for adjusting cards; the unaided eye is not to be wholly trusted, because circumstances vary under which you have to adjust your cylinders, such, for instance, as shadows and reflections of light, clear and cloudy days, etc. The best plan is to utilize a sense of touch as well as sight by using gauges to assist the eye; one will be a check on the other. The fancy is set by the ear alone, and if both it and the main cylinder are in good order it may be set pretty deep without

giving trouble. The fancy has been called the "scavenger" of the carding engine, and the name is very appropriate, especially when dirty, low stock is used. In that case the fancy can be made to keep the main cylinder fairly clean for a considerable period. Always set your fancy as close as you deem practicable.

A common error is made in adjusting one end of a cylinder to its proper place, and then completing the other end. It is clear that, when one end is set in position and the other brought down to the same distance, the end first treated will have become too close, provided the article was too high in the beginning. Bring the cylinder nearly to its ultimate position at each end, and then by alternate tests at one end and the other complete the operation, noticing that no wool or other substance is between the journal and its bearing.

In tightening the nuts during adjustment care should be used not to twist the poppets, or the cylinder will be slightly elevated, until, after working for some time, it will gradually settle down, and thereby cause the point to be de-

stroyed by the cylinders rubbing together. A wooden mallet or small lead hammer may be used to give a smart blow to the journals in order to discover if any of them have been raised by screwing the poppets tight.

A great deal has been said about the setting of ring doffers; but we shall give the only proper way here, which has been arrived at by long practice and by study. In their relation to the main cylinder, ring doffers should be adjusted both alike; that is, both the same distance from the main cylinder, and that distance may be described as being just as close as you can get them and prevent their touching. This statement is made, notwithstanding the opinion I have often heard maintained by some carders, that the upper one should be farther off than the lower one. The writer has often been amused to hear this wrinkle explained somewhat as follows: That as the fancy will throw out some fibres, and these must fall on the top doffer only, it becomes necessary to set the lower one closer to make up for its deficiency; in other words, to give a surplus to the

lower doffer in some mysterious manner of more than its share of the wool from main cylinder to balance the flyings from fancy given to upper doffer. A moment's reflection ought to convince any one at all conversant with the subject of the fallacy of such reasoning, for, owing to the manner in which the rings are arranged, it is evident that the lower ones only take off such wool as is left *between* the upper ones.

These views, published in the first edition of this book, in 1874, soon afterwards gave rise to a great deal of discussion and controversy, mostly carried on in the "Industrial Record" of New York; and after many indiscreet things had been said, it was declared very unanimously, that the top and bottom rovings were never alike, and in all the best mills were always kept apart, and spun on different mules,—that is, tops on one and bottoms on another; that the accidental mixing of these top and bottom spools would ruin the work, etc., etc.

In the attack made on my theory it was just as confidently and unanimously asserted that

setting the doffers at varying distances from the main cylinder made all the difference in the world. It was maintained that, by setting the top doffer off, the slubbing could be made lighter, and by setting the bottom doffer closer to the main cylinder its product could be made heavier. Now, if this was true, the dullest person could see that the product of both doffers could be made uniform in size, and therefore it would be folly to keep the spools from each doffer apart. The fact remains, however, that this pet notion is the outcome of ignorance, for in the best mills in America they still continue to keep the spools apart, and in all mills where they spin particular work, which proves conclusively that the doffers do *not* turn off an equal-sized product, in spite of the legerdemain.

The idea is wholly opposed to good carding, and by thus interfering with the best relative position of the doffers to the main cylinder, in a bungling attempt to get the stubbings alike, a great deal of work has been spoiled.

The proper position for a doffer is as close

as possible; put it there and leave it there, resting assured, that the more you deviate from that position the more you sacrifice your advantages, and the more your rovings will suffer.

Under the head of Doffers will be found a practical way by which the product from both doffers can be made very nearly alike, and it is the only feasible way there is of attaining that end.

The doffing-comb needs very careful adjustment, or much vexation will ensue. The toothed plate should be in a perfectly straight and level line. The centre of the comb is best a little above the centre of the doffer, and the stroke should be so arranged as to fall an equal amount above and below its centre. On short stock it is sometimes necessary to give the comb a higher up-stroke, and for long common wool, with a high doffer speed, a lower down-stroke. With tender stock it is also advantageous to shorten the throw of the crank so as to make short strokes, and to speed up the comb. The opposite treatment is necessary on longer stock.

The proper motion of the comb has much to do with keeping the doffer clean and making even work. It should not strike the doffer, but should be set as close as possible. The best way to set it is, when the card is running, by the ear, letting it just touch, and then setting off the least amount. It must also be carefully cleaned whenever it requires it, and not neglected; the teeth should all be in good order, as well as all joints kept tight, to avoid rattling. The speed should be kept as low as the work will permit, with a short stroke, to avoid unnecessary wear. A comb in perfect order should run noiseless, or very nearly so. It is pretty sure evidence of a careless workman to hear all the combs rattling when one goes into a mill, for there is no excuse for it.

The modern so-called "noiseless" combs are only noiseless when properly attended to; but they possess great advantages over the old-fashioned combs in the mechanism employed for the conversion of rotary into oscillatory motions, which, by many ingenious devices, can be easily made to run almost noiseless, while attaining a

much higher rate of speed than could ever be got out of the old comb motion, and the short, quick stroke so obtained is a grand thing for short materials, as shoddy, etc., because it helps support the lap or sliver on leaving the doffer, and still keeps the latter clean by its quick movement. For long wools, however, the old slow, long-stroke combs are the best.

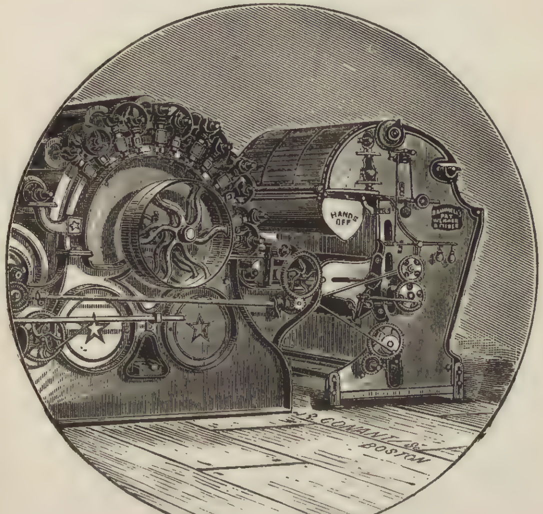
All the combs we have referred to, whether new or old style, are those which swing with an oscillating movement, and whose blades operate in a curve in front of the doffer. This class of comb are of more modern use than the old combs, which were provided with flexible arms, attached at one end to the arches of the card, and at the other to the uprights, to which, lower down, the comb bar and plate were fixed, at right angles to the arms. The uprights, passing downward, were at their lower ends journalled to a face-plate and wrist-pin, at each end of a shaft, driven at a considerable speed. This style of comb for some classes of work cannot be excelled, and is far superior to the modern comb for very short materials, shoddy, mungo, etc.

The reason is, that as it moves downward it *approaches* the doffer; but the moment its upward movement commences it recedes from the doffer, and is farthest from the latter at the point in its upward movement where it is closest in its downward movement. The result is, it can be set so as to touch the doffer in going down, without injury to it, and this is a very useful feature, as it not only removes the shortest fibres, but has a good effect otherwise on the doffer. If this movement could be combined with the noiseless motions, we should have, then, a satisfactory comb.

THE FEEDING OF CARDING ENGINES.

From the first invention of rotary carding, all raw materials have been fed on by hand, until recent years. In the beginning, before the invention of the feed-rolls and endless apron, or lattice, the tufts of wool were lashed on to the first roller of the card, by taking the wool in the hand and holding it in different parts against the revolving surface, allowing the teeth to seize and draw out the fibres from the

THE OLD WAY.



THE NEW WAY.

hand. Then the "feed-sheet" of cotton cloth was invented, and the feed-roll, revolving slowly in a concave dish, held the wool by means of pressure applied to the roll, which, first, was plain, afterwards fluted, and, finally, covered with coarse clothing. The feed-sheet was used for many years, until the lattice apron superseded it. In all these devices the wool was taken from the feed roll or rolls directly by the main cylinder; then came the tumbler interposed between the feed-rolls and the main cylinder, and, lastly, the wooden licker-in was added, until it was superseded, many years afterwards, by the metallic burr-roller, which was the invention of Francis Alton Calvert.

The feeding of raw wool mechanically has occupied the minds of many inventors throughout the manufacturing world for a great number of years past, but more particularly since about 1860. Hundreds of patents have been obtained for devices seeking to accomplish this operation. Every imaginable arrangement has been tried, but most of them discarded the old plan of weighing the material, as

when the operation is performed by hand, expecting that by the aid of mechanism a means could be devised for measuring the wool, or otherwise gauging its thickness. It would be useless for me to attempt any description of this mass of projects here, so we will consider only two of the most prominent inventions, each being a representative of a distinct class of mechanism, around one or the other of which all the remainder range themselves.

These classes consist of measuring devices and of weighing devices. Beginning with the former, we shall single out, as the most prominent representative, the invention of Jean Sebastian Bolette, of Goffontaine, Cornesse, Belgium, who obtained a patent, August 23, 1864. In this device the wool was thrown into a case having a lattice apron in the bottom and a toothed apron in the rear. The lattice travelled towards the toothed apron, carrying the wool along with it, which was then raised by the toothed apron, until near the top it came under the action of a cylinder armed with teeth, whose object was to equalize the material on the

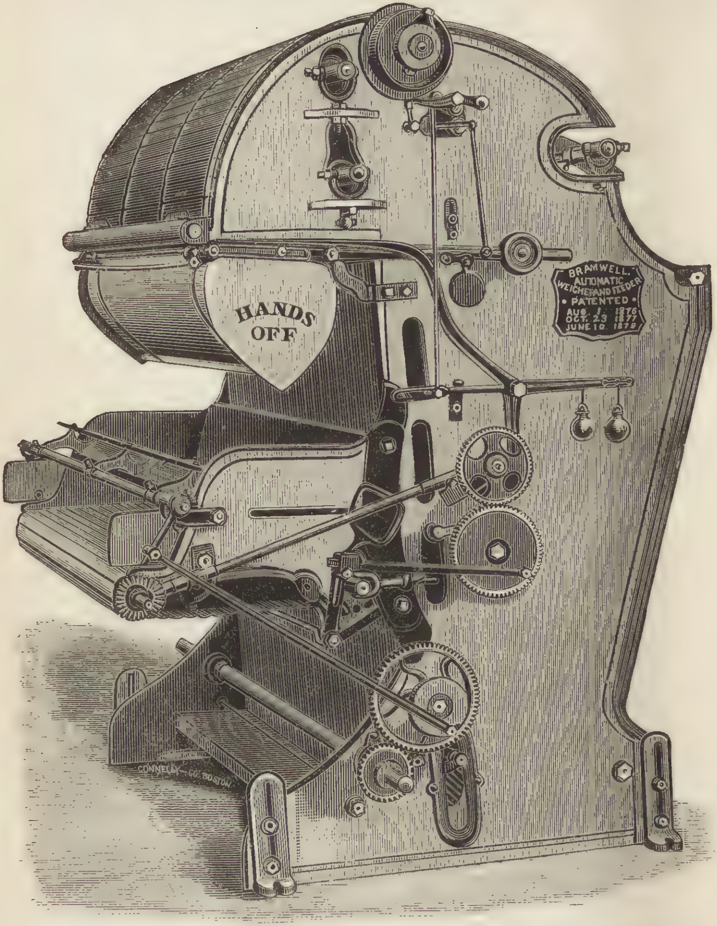
toothed apron. Passing the latter the wool was projected by a rotary beater into a throat composed of a lattice in the bottom and an adjustable hinged metal plate on the top, which, by means of a screw, could be raised or lowered, in order to make the throat narrower or wider. The operation of the machine was such that the throat was kept constantly filled, and the surplus returned back into the case by the beaters. By raising and lowering the movable plate, the feed was to be made thicker or thinner, as desired.

This apparatus found its way to America, and the manufacture was commenced by Messrs. Chapin & Downs, of Providence, R.I., who built a number of them. It was further altered, and a patent issued to G. S. Harwood, of Boston, February 16, 1875, for a throat having movable surfaces, both top and bottom, in lieu of the metal plate, which had been objected to, on account of retarding the progress of the material. In order to make the feed lighter or heavier with this new arrangement, the two aprons forming the throat, or chamber, were

fixed so that their speed could be changed to run faster or slower.

The above invention of Bolette serves as a type for many others of its class, both preceding and following it, that is to say, it *measured* the wool as it was continuously supplied to the carding machine. Depending, therefore, altogether on the bulk of the material for regularity, it necessarily followed, that as the bulk varied, or other conditions of the material became changed, so did the amount delivered to the card vary. Or if the material was composed partly of open, light, or fleecy wool, and partly of heavier, shorter, and consequently less bulky substances, the tendency was to separate them, which was a very serious matter. If, also, a portion of partly carded material was at any time added to the raw wool in the case, the same unequal result followed; for the carded material would quickly fill up the space in the chamber, which would otherwise contain double the quantity of raw wool.

Coming now to the weighing devices, and selecting the most successful from the great



"THE BRAMWELL AUTOMATIC WEIGHING AND FEEDING MACHINE."

number of unsuccessful ones, and we have the apparatus invented by the writer, and patented in 1876.

In this machine the wool is put into a large box, or case, having a grating in the bottom for the exit of refuse, and an elevating toothed apron in the rear, covered with teeth of a peculiar construction, the result of much study and experiment. These raise the material out of the case until near the top it is brought under the action of an oscillating comb, having a slow but long sweep in front of the apron. This comb is armed with teeth, and operates in such manner that the surplus wool is combed off the apron and the rest left evenly distributed amongst the teeth of the latter. On the other side of the toothed apron there is another and shorter one, having a more rapid movement. This is provided with flexible strips of leather, which sweep off the wool from the teeth, and convey it, in connection with a hollow or concave shell, or dish, into a weighing-scale. The scale is formed of two curved wings, held together by suitable weights, and the whole suspended

on steel knife edges, and balanced with movable weights, which can be fixed to weigh any amount desired. When the scale has received its proper amount it liberates a small trigger, which causes a projection to catch on one of the teeth of a revolving disc, which is connected with a novel automatic clutch, which disengages the driving belt operating the toothed apron, thus instantly stopping further delivery of material to the scale, which now remains at rest. When the proper time arrives, the wings are opened apart and the wool is deposited on to the feed-lattice, in a perfectly opened-out state, and in excellent condition for the cards. The scale is now closed and returned for more wool; at the same moment the toothed apron is set going, and the delivery is carried on as before. While the scale is, however, receiving a fresh supply of wool, that which was previously discharged is moved along positively on the feed-lattice, to a fixed distance, at every discharge, thus leaving a clean open place for the next weighing to fall into.

This machine takes up about the same room as the ordinary feed-table, and requires but little power to drive it. It is complete within itself and perfectly automatic. It will give more perfect feeding than any other means that can be adopted. It will *mix* the wool, and render it, if of different kinds, more homogenous, thereby making a better yarn. It will take out a large amount of whatever refuse matters the wool contains, and therefore it preserves the card clothing considerably. The cards will clean easier by its use, and they will turn off 20 to 30 per cent. more work than with hand-feeding. One "hand" can run from 10 to 25 of these feeders, the number depending on the arrangement of the cards; or one hand can run three complete sets of three cards per set. The machine is ornamentally designed, light, handy, and will not get out of order. All the bearings are self-adjusting, and every part is built so as to be interchangeable.

In proof of the above assertions a few figures may be given regarding the success already achieved; for it has been said that "the value

of an invention can only be measured by its success." The first machine was sold in March, 1878, and up to the present writing, January, 1881, there have been put to work over 1,800 of these machines. All the largest mills in America have adopted them, and there can be no doubt that a permanent revolution has taken place in the feeding of raw wool to the first card.

In England some of the largest manufacturers, after extended trials, have adopted it, among whom we may mention the firm of Isaac Holden & Sons, who operate over 500 double carding engines, and 300 combs, being by far the most extensive wool-combers in the world. Mr. Holden has devoted many years of his life to improvements connected with the carding machine. We may name also the firm of John Crossley Sons & Co., the noted carpet manufacturers of Halifax, who employ nearly 7,000 people, and who adopted the machine after numerous trials. In France it also gave satisfactory results in one of the largest manufactories. In the fine woollen trade in Hudders-

field it met with unqualified success, although tried on a set of cards having direct feeding all through.

For such a record there must be something of unexceptionable excellence, and it can be summed up in a simple statement of the principles on which the machine is designed and constructed. These are, firstly, to get the material into as uniform condition as possible before being weighed. Secondly, to so arrange the weighing apparatus that while perfectly controlling the supply of material it shall be free from attached mechanism, and consequent friction, thereby maintaining its sensitiveness unimpaired. Thirdly, to so operate the mechanism that at each discharge of the weighed material it shall be forced to cover an equal amount of space on the feed-lattice. Fourthly, that this operation shall take place at uniform intervals of time.

We have, then, briefly, a given *quantity* made to occupy a given *space*, at uniform intervals of *time*.

All three of these elements can be changed

independently of each other, thus furnishing ample opportunity for making any changes in the size of the carded product, or in its weight, and allowing for any desired modifications in the thickness of the feed, etc.

FEEDING THE PRODUCT OF ONE CARD TO ANOTHER.

After the raw wool has passed through one card it must be transferred to another, and there are three conditions in which this may be done: —

First, in the form of a film, or gauzy sheet of fibres, in successive layers, called the *lap* system.

Second, in the form of a flat ribbon or band, of several thicknesses of fibres, called by various names; but we will name it the *ribbon* system.

Third, in the form of rope, wherein the fibres are twisted around each other, by rolling contact against the face of the doffer. This is called the *side-drawing* system.

The oldest method of feeding is by the first

system, in which a drum was placed in front of the doffer, around which the film was allowed to wind until a given thickness was attained, when, by means of a small roll resting on top of the fibres, which (by their combined accumulation) became elevated, until a bell was rung, the attendant removed the lap so formed, and transferred it to the next card. This method has been abandoned, on account of its not giving regular work. There are several reasons why such is the case, which it is needless to enter into here, seeing that the plan is obsolete.

Another method of carrying out this system is by the lap machine, which *folds* the film, one layer upon another, until of the desired thickness, when it is continuously wound upon a spool the full width of the card, and then transferred on to a feed-lattice, where it unwinds, and enters the feed-rolls. It is customary to have two or more spools unwinding at the same moment, one lap on top of the other, in order that they may neutralize any differences in their respective thicknesses, and also

to break the joints, the end of one lap coming in the middle, or thereabouts, of the other, so as not to affect their continuity. The thickness of each lap is in proportion to the speed at which it is caused to wind around the spool; for if the lap travels towards the spool slowly, then it will receive more layers of the film, and *vice versa*.

Two forms of lap machine have been successfully used, the original one being known as the "Ferrabee Feed," from James Ferrabee, the inventor; the other, known as the "Blamire Feed," but which, in its modified form, should be known as Marsden and Blamire's, being the joint invention of these two Huddersfield manufacturers. The difference in the two feeds last mentioned is merely in the mechanical arrangement for carrying out the idea. In FERRABEE'S machine the film is carried up from the doffer-comb on a lattice apron, mounted on a framework jointed at the top, similar to a pair of dividers, one leg of which may be imagined as carrying up the wool from the doffer, and the other leg being caused to

open and shut. The film arriving at the top of the framework came down on the other part, and there was folded back and forth, on a creeper or lattice, slowly moving at right angles to the jointed lattice frame. The latter could be made to deposit as many thicknesses as desired on to the transverse apron beneath by running the latter faster or slower, and the lap so formed was wound on a large spool, ready for the following card.

BLAMIRE'S FEED consists in a lattice apron projecting outwards from the doffer, so that as the film leaves the doffing-comb its whole width falls, as in the Ferrabee machine, on to the creeper or lattice; but instead of going upwards, like the latter, it runs nearly level, leaving ample room beneath for the transverse apron, which moves back and forth on a track, and so forms a lap, from the film being laid one layer on another, until of sufficient thickness, which can be varied by altering the relative speed of the delivery apron and the travelling apron beneath. The latter is caused, at every back and forth movement, to advance the apron forward a

certain distance, carrying the lap along until at the end a pair of rolls receive the bobbin for the lap, which is passed once around, and then left until full, when it can be changed without stopping the machine.

It will be understood that in both of these machines the apron, or lattice, which receives the folded lap is caused to travel in a direction at right angles to the outcoming film of wool from the doffer, and that, as a consequence, the fibres pass into the next card in a direction at right angles to what they left the previous card, or sidewise instead of endwise. For yarns intended for warp this is not an advantage; but for filling it does no harm, and it is for many classes of goods of value, as it gives more points, and will, therefore, "mill" firmer in the cloth. A new feed has recently been brought out in Philadelphia, which relaps the lap by the addition of another story, so to speak, to the machine, as we have described it; in other words, the lapping device is reduplicated, and it follows that the fibres become againr eversed, that is, brought back into the

same position as when they left the last card, and therefore they now enter endwise. This is claimed to be a considerable advantage; but it has the serious drawback of a much added complication of parts, and of course extra cost, both in the first place and for subsequent repairs.

Coming now to the second method, and we have what is known as the "SCOTCH FEED" as a means of carrying the wool forward. This feed can be best described as a dividing line between the lap and side-drawing. The flat ribbon of fibres, which is some 3 inches wide, is conveyed overhead to the receiving card, where it is passed backwards and forwards (parallel with the feed-rolls) on the feed-apron, flat side down. By the slow movement of the apron the ribbon is laid in such manner that each crossing overlaps the preceding one about one-half its width, thus making a succession of narrow laps, each half its width in advance of the other, and so on continuously.

Having reference now to the third or side-drawing system, we find two distinct methods

of feeding it, viz., by means of intermittent "spools," "balls," or "cheeses," as the case may be; and the continuous method, invented by James Apperley and William Chissold, both manufacturers, near Stroud, England, their invention being the well-known "Apperley Feed." With the intermittent method there are two ways of transferring the drawing, viz., by the common side-drawing spools, and creel, and by the "balling head." The latter is a modification of the other, consisting in devices for winding the spools or balls under considerable pressure, and of a shape similar to a cheese, which gives the name to the apparatus of the "cheesing machine," by which name it is known in some parts.

This machine was patented August 20, 1863, by William Richardson, and subsequently improved by Platt, of Oldham. It has since been manufactured, under the joint inventions, by Messrs. Platt Bros., the extensive machine-builders; and it is a matter for surprise that only recently has it found its way to this country. Improvements have been made by

Tatham, of Rochdale, and by Leach, of same place, both builders of this and other woollen machinery. In Platt's machine the full spool is changed automatically for an empty one, and then must be removed, thus requiring a little attention for every spool. The improved machines have from 12 to 20 empty balls or spools, held by clips around the periphery of a wheel, or in a suitable receptacle, and these are automatically fed one at a time; the full ones being dumped out at the same moment. Platt's machine, however, makes generally the most solid ball, and therefore, as will be seen farther on, allows for perhaps a trifle more doubling than the others.

The advantages derived from the use of the Balling head are, that the balls can all be made of equal size; that double the quantity of wool can be condensed into the same area, and that considerable labor is saved. The objections are, that they take up space in the alley-way between the cards; that they are costly, and they are not continuous.

Besides the Scotch feed there is only one

other which is continuous, viz., the Apperley or Diagonal Feed. When Apperley first conceived this invention he had holes at each end, about 2 inches apart. Into these holes pegs could be placed; and a girl was employed to take the "drawing" as it was delivered from the first card, and pass it around these pegs, from side to side, at the same time withdrawing the forward ones, nearest the card, and replacing them as the feeding progressed, in order to release the drawing so it might pass into the feed-rollers. Chissold suggested, or applied, the traversing guide and rolls, and finally the drop levers at the ends, and the spike straps, which completed the machine; and it is wonderful that although thousands have been sold in both Europe and America, it has remained ever since in the identical shape that it was when first put upon the market by the inventors, in or about 1849 or 1850. The writer has in his possession a lithograph, published by the inventors in 1851, which is a correct representation of the machines of the present day. It has not been because it was faultless that im-

provements have not been made in the machine, for it is well known by all who have had experience with it that there is ample room in that direction.

Coming now to the question as to which of these systems and methods is best calculated to give regular work, we find many conflicting claims urged by their votaries, which we, as instructors in the art of carding, shall proceed to straighten out to the best of our ability. In doing so we shall give to each just what belongs to it of practical value, so that the reader may have as clear an idea as possible of their respective merits, and be thereby enabled to judge correctly as to which will best answer his wants, and how far he may already be in possession of the best system of transferring his material from one card to another.

The fundamental idea underlying all machines of this class is, how best to obtain the utmost amount of *doubling*, in order to more thoroughly equalize whatever irregularities there may exist in the product of the preceding card, and thereby turn off a more equal pro-

duction from the succeeding card. The machine, or system, therefore, which will enable us to double up the most, will undoubtedly best answer the purpose.

Taking the two systems of lap and side-drawing in their entirety, we must first of all decide which best fulfils the objects pointed out; and that will not detain us, for at once we say the lap. Our reasons for this decision may be briefly stated, as follows: it has always seemed that to twist the wool into a rope, and then immediately pull it apart again, was a wasteful operation; first, because it injures the fibres; second, it also injures the card clothing; and, thirdly, it is in the wrong shape, being round like a rope, for the reason that in carding we want perfect distribution of the wool, and therefore ought to have the material flat and loose. So far as general principles go, then, we prefer the lap; but there is the very important question as to which enables us to get the greatest amount of doubling, and we are obliged to consider this matter in its relations to an intermediate card separately from a finisher,

for its application to one or other of these engines alters the whole subject, as we shall show.

ON THE APPLICATION TO AN INTERMEDIATE CARD.

With the side-drawing laid on by the Apperley Feed, we can obtain from 30 to 60 rows all entering the feed-rolls at the same moment, which, being drawn into one at the other end of the card, give just so many doublings. More than this can be crowded in; but that involves making the drawing thinner, which is a loss of doubling, from the fact of not containing so many films twisted around the rope; and it is further objectionable, because, if too much crowded, it results in inequalities caused in various ways, but principally by forcing the feed-rolls to spring in the middle.

Setting up a common creel instead of the Apperley Feed, and we can get one drawing per inch in width of card, or 60 drawings (spools) to a 60-inch card; and not conveniently more than this number, on account of the size of the

spools, which, if more are added, involves a creel of too large a size.

Taking now, instead of the last, a balling machine, and we can increase the number to 90 balls, still keeping the creel of convenient dimensions. This is occasioned, as already explained, from the cheese-like shape of the balls, and their compressed form.

This brings us now to the lap and its applications, and we have two devices, the Scotch and Blamire. With the first named we can obtain but little doubling, and the only advantage it possesses over the Apperley is in its placing the wool on the feed-apron in a loose state, instead of a rope, and perhaps a practical advantage in not laying the material on diagonally.

With the Blamire we get, say 90 or 100 doublings on each lap, and by placing two of these together on the feed-apron we obtain 180 to 200 doublings. More than two laps may be added; but it involves making them thinner, or otherwise risking inequalities, by springing of the feed-rolls, and thereby being imperfectly

held, or of injury to the fibres by an excessively slow motion of the feed-rolls, which must be sped slower in proportion to the thicknesses offered.

From the foregoing it is plainly evident that the matter lies between a side-drawing fed with the balling head and a lap fed with the Blamire Feed. The victory seems to belong to the latter; but there is the question of the side-drawing's helicoidal form. Supposing that to a 60-inch card 90 balls are set up, and each drawing to have made 10 turns in travelling across the face of the doffer; during its formation, then, 900 doublings is the result, which is near enough the mark for our purpose, and this settles the claim of the balling head as the best known means of feeding an intermediate carding engine.

ON THE APPLICATION TO A FINISHER CARD.

If side-drawings are fed to a finisher from spools, or balls, they must necessarily pass straight through the card, and therefore there is only so much doubling performed as is attributable to the helicoidal wrapping of the film

around the body of the rope; and, as we have seen, this only amounts to some ten or a dozen doublings, therefore we at once abandon such means of feeding the finisher, however applied. There is, then, only one way left applicable to the side-drawing, and this is with the Apperley Feed. As we have already seen, this appliance admits of from 30 to 60 strands or rows, being laid diagonally across the feed-board, the ends of which are all in the bite of the feed-rolls at the same moment. With 30 as the number, each of 10 turns, or wrappings, and we obtain the total of doublings at 300. But these are all made from the previous card during an interval of a few minutes, and therefore they represent the irregularities that may, just at the moment, have passed through the previous card, and such irregularities are duplicated continuously as fast as they occur. Suppose, for instance, the previous card has just been cleaned, and the teeth are replacing the material cleaned out, by appropriating the fibres passing through the card, then of course the drawing for a considerable length must be finer

than before, and less of it; in which case it is out of the question to suppose that the 60 strands can be otherwise than wholly or considerably less, and cannot by the doubling effected equalize themselves. With the Scotch Feed it is practically the same in that respect; therefore these machines by their directness are not all that could be desired; but yet there cannot be a doubt that the Apperley Feed is the best means of feeding a *side-drawing*, or rope, to the finisher.

In the application of a lap we have the means par excellence for feeding a finisher, and, as already said, the Scotch Feed being too direct, we have only the Blamire left for consideration. With this we get the wool in a loose, flat condition, well suited for equal distribution over the whole surface of the card wire, and we get on the finisher nearly as much doubling as can be had in an intermediate card,— a desideratum not possible of accomplishment in any other way. Taking two laps, we will suppose that each have required a half hour in formation, and that an extra one is always kept ahead, to be interposed

between each one and the next following; then if the previous card has been cleaned, as before supposed, and a consequent thin portion of one lap produced, we have a means of equalization furnished by the interposition of the other one, which has not that defect. This, then, is the best known means for feeding a finisher carding engine.

Hitherto, in these remarks, we have supposed a set of three cards, but reverting now to the employment of two only in a set, and we are confronted with the fact, that the lap feed is an indispensable means for obtaining an equal or regular product of the finisher under these conditions.

The best-known means, then, for feeding a set of three cards, will require the BRAMWELL FEED for the *first card*; the BALLING HEAD and CREEL for *second*; and the BLAMIRE FEED for FINISHER.

The best-known way to feed a set of two cards would require the BRAMWELL FEED for the *first* card, and the BLAMIRE FEED for the FINISHER.

We like to give good reasons for all we say, and one object in writing this book is, to plainly state the practical value of such appliances as are for sale, and to do so without fear or favor; to straighten out conflicting claims for this and that, which tend to perplex both carder and manufacturer until they know not which is best suited to them.

Hoping we have given only good and sufficient reasons for all statements made, we will leave the subject of automatic feeding with the remark, that the field is wide, and reward certain, to the inventor who can produce a feed for the finisher card that will be emphatically a self-feed, to take up no more room than the ordinary kind, and to be *continuous*.

None of the feeds for finishers are entirely satisfactory, — far from it, — and there cannot be a doubt but we shall, before long, have a feed produced to meet modern requirements.

PROPER CARE AND MANAGEMENT OF FEED-ROLLS, LEADERS-IN, AND TUMBLERS.

The subject of these remarks is of more consequence in successful carding than some carders appear to think, for we find very few mills where these parts are kept in good order. In fact there is no portion of a carding machine so badly neglected as the feed-rolls and accessory cylinders. This state of things is to be deplored, and leads us to devote our attention now to a consideration of how best to keep the parts in good order.

It is safe to start out with the assertion, that if wool enters a card irregularly its exit will be irregular, and no subsequent arrangement will completely remedy such defects. If each card is faulty in this particular, those defects are but multiplied. Steel ring feed-rolls and leaders-in are the latest novelties, and they are undoubtedly the best; but, owing to their great expense, and the fact that the difference in first cost does not justify the outlay, when compared to judiciously arranged diamond-point cylinders, it is

to be supposed they will be slow of adoption for intermediate and finisher cards.

For the first card of a set the metallic feed-rolls and the steel ring burr-cylinder are indispensable ; there can be no doubt on that question, so we will, for the present, confine our remarks more particularly to the best form and arrangement of these parts for the second and third cards. A wooden "licker" or leader-in should never be used, but instead thereof we recommend the iron cylinder for this purpose, as it always keeps true, besides forming a solid basis for the clothing. Whether it is iron, or wood, the clothing should be stretched on extra tight, so as to maintain a stiff, upright position to the teeth against the strain they have to bear. No. 22 diamond point for ordinary to fine work will answer very well. The bottom feed-roll should be covered with the same clothing, and the top roll with "Belgian" pattern diamond point, which will be easier to keep clear.

The wiper or small stripper may be covered with ordinary No. 30 to 32 round wire, ground smooth, being very careful not to injure the

teeth by pressing them forward with the grinder. There is nothing so hard to grind in a card as this roll, on account of its small circumference, and if done carelessly neither it nor the feed-rolls will work satisfactorily. Don't try to make a fine point on it; smoothness is more essential.

For some sorts of wool the Belgian pattern card covering might not be so suitable as round wire or diamond point, having longer teeth than the Belgian. But for fine wool or thin feeds the latter clothing has some advantages.

Many carders are troubled with the diamond point leader-in filling up with wool and gumming in a short time, as they are then difficult to clean without injury to the teeth. They soon lose their "point" also, and are never good for much afterwards, as it is next to impossible to grind a good point on them when worn. These difficulties are at once remedied, and with a saving in waste, besides improvement to the work, by adopting the following plan, namely, to place a small fancy in the hollow over the leader-in and tumbler. It should be 5 inches

in diameter when covered with ordinary fancy wire, and driven with a straight belt from the end of a stripper. Its surface speed should be faster than the leader-in, and it is set so as to raise the wool on the latter effectually, precisely as the fancy does on the main cylinder. This enables the tumbler to clear the leader-in thoroughly at each revolution, and the latter may be run constantly for months without cleaning, thus saving several pounds of waste each week. The "point" will always remain in first-rate order on the leader-in, by the use of this fancy, thus enabling it to comb out the fibres from the feed-rolls in the best possible manner.

The "tumbler" needs particularly to be smooth, as well as to be ground and kept to a good working point, so as not only to clear the leader-in regularly, but also to part with its wool to the main cylinder with great facility.

The size of wire on a tumbler is not of much consequence, but No. 30 to 32 will do, and it must always be kept perfectly true.

We have already spoken in our review of the carding engine concerning the best diameter

of these rolls and cylinders, and there only remains to be said how to best adjust them: first of all see that they are level, then begin by first setting the tumbler as close as possible (without touching) to the main cylinder, then the leader-in and lower feed-roll to each other, and the tumbler as close as can be. The upper feed-roll may be set $\frac{1}{16}$ inch from the leader-in and lower feed-roll. The wiper or small stripper is adjusted close to the upper feed-roll and leader-in, so as just to clear; the fancy quite hard (at first) on leader-in, but just to clear tumbler. It will be seen that to adjust these cylinders as described they must be made *true*, and so maintained, or it cannot be done; thus resulting in much loss of efficiency in regard to thorough opening and carding of the wool, besides an increase of waste and loss of time in cleaning the same from the various cylinders. On the other hand, if the cylinders are true and arranged as described, the feed-rolls will keep clear, the point of leader-in will be preserved for years, the work will be much improved, and a considerable amount of worry

saved the carder. To some carders these suggestions may seem commonplace ; but from my own observation I know they will be of deep interest to the majority, who, under less favorable circumstances, have not had chances to become posted, but are anxious to learn ; it is for such I am trying to make plain what I consider essential parts of successful carding.

In describing this arrangement it must be understood to refer to the modern card machine, with the leader-in revolving in the same direction as the main cylinder, the latter clearing the tumbler, which runs in the opposite direction. The suggestions apply also to the Apperley Feeder, which contains its own feed-rolls, as well as to feed-rolls, etc., for the ordinary spool rack or creel, and which are usually attached, to the card-frame. Arranged as described a combing operation takes place at the very beginning of the process, which is of the greatest possible value. The wool is entered into the card with great regularity, free from lumps, or other irregularities, and possibly one half the carding may be done at that point

before going further. There must be no accumulation of fibres, or dirt, allowed on any of these rolls or cylinders; and I would particularly impress upon the carder to study this matter for himself, and I think he will need but little urging to afterwards spend great care on this generally despised part of a carding machine.

THE MAIN CYLINDER.

If a main cylinder be covered with "sheets" of card clothing they must be tightly stretched upon its surface, otherwise the centrifugal force to which so large a cylinder, with so much surface speed, is subjected to, will cause the sheets to belly out when running, and so destroy their own points as well as the other cylinders against which they strike.

In cleaning a main cylinder, the hand comb, if used, should always be drawn *straight*, and not raked crosswise, thereby spoiling the regularity of the teeth, as so many are spoiled. The hand card is the best thing, if it can be made to sufficiently cleanse the dirt from the cylinder.

A main cylinder, once ground sharp, should not again require anything further except smoothing over once in a while with a "fiddle," as the fancy ought to keep it in good point and smooth. It is a common practice, if a main cylinder becomes out of true, to put on the grinder and face it true, afterwards reversing and grinding the point. This is not very creditable to any carder, and would pay him and his employer much better in the end to take off the clothing and "turn" the cylinder true. It would take more time and trouble to do this; but a good workman will consider neither of these, but only that which is the *best* thing to do.

As a carding power we do not place great value in the main cylinder, looking upon it rather as a conveyer of the wool from point to point, and as a base for other essential carding features.

We think it is wrong, also, to spend much time in the efforts to produce a very fine point on the main cylinder, for you thus only defeat, in some measure, your doffer and workers,

which must always have the ascendency in regard to point.

But what you do want in a main cylinder, above all other things, is perfect truth and smoothness.

THE FANCY.

This cylinder has been truly styled the "scavenger of the carding engine;" but the remark contains the greatest force when used in connection with the carding of shoddy, mungo, etc., where you can dig into the wire of the main cylinder. With clean, open fibre of decent length, the fancy loses much of its importance, for it is not necessary then to set it in so deep, such material being easier to raise upon the surface of the main cylinder, and being more liable to "fly" if much force is exerted.

The fancy, though different in its functions from all other parts of a carding machine, must in any case be considered as a most important auxiliary, and it needs much experience to understand its peculiarities, as well as judgment to successfully manage it.

The long and delicate teeth, offering but little resistance to shocks, etc., often get jammed during transportation, and it is of the first importance to raise all such teeth to the common and original level immediately after the clothing is on. This can be done with a knife-blade or awl, being very careful not to strain the teeth too far back, and to touch only those that are out of position. Such teeth as point sideways should also be straightened, for they often cause a fancy to work badly.

Having carefully gone over the whole surface, it may now be set very lightly to the grinder, so as to touch only such places as are higher than the common level. Gradually set a little closer as the roughness wears off the point, and run until the entire surface appears to have been slightly touched and to present a more uniform appearance. Now remove it to its place on the card, and put on a straight belt to the large stripper pulley on the main cylinder; set it tolerably hard to the latter, and start up, running the main cylinder backwards; but be sure your fancy is perfectly level. This pro-

ceeding will cause the wire points to rapidly pass through each other, smoothening them from any roughness, and putting the fancy in prime condition. Oil should be freely sprinkled on a cleaning card, and the latter held gently on the fancy while in motion, which will lubricate the points and assist the smoothening. It is well to ease the fancy towards the end of the operation, so as to touch lightly, and run it thus for some time.

Allow yourself plenty of time, and don't attempt any carding until you feel certain the fancy is in as good condition as you can make it. It is advantageous at the last moment to take a wad of oily wool and, holding it on lightly, cleanse from the teeth all emery or wire-dust and dirty grease.

The best clothing for a fancy is that which is finer than the main cylinder, open set, and elastic. A stiff fancy is not of much use, nor is one too full of teeth, nor too coarse, nor too straight in the angle of the teeth. In the latter case they can be improved by setting the fancy in the grinder-frame, with the teeth pointing

from you, and causing it to revolve towards you. Now place the turning-rest on the brackets in front, and fasten in the tool-post a thin piece of steel, — part of a saw-blade will do, — $1\frac{1}{2}$ or 2 inches wide, and square at the end, but with the corners rounded off a little. Set this so it will project about $\frac{1}{4}$ inch beyond the points of the teeth, and, with the fancy revolving as described, move the tool slowly and steadily across once or twice, or until it seems to have sufficiently changed the angle of the teeth.

Another plan is to set the fancy in the grinder, with the teeth pointing towards you (the grinding-pulley or cylinder being on the other side), and then set it close to the grinder, which in this case is revolving from you, so fixed that the friction of the grinding surface against the teeth will cause the fancy to rapidly revolve; and it must be retarded by gripping the shaft in the hand, no belt being used. This will press the teeth to a sharper angle and grind them at the same time; but it must not be set too deep at first, or it might disarrange the teeth.

The office of the fancy ends just at that point where it raises the wool fibres from the main cylinder without entirely loosening and throwing them out; in other words, the operation is performed to perfection when the wool lies on the surface of the main cylinder like the nap on cloth after gigging. If the speed is in excess the fibres will be thrown forcibly off, the current carrying them along, and propelling them into the atmosphere, making much unnecessary flyings. If the speed is too low the wool will not be effectually raised, causing the whole machine to carry an excess of wool. When, however, the mean between these two extremes is reached, then there will be no trouble; the card will work all through clear of accumulation, without making any visible flyings, although the fancy may be set quite hard against the main cylinder, and it always ought to be as close as is practicable, for reasons already explained.

I think fancies as a rule are run at a much higher relative speed as compared with the main cylinder than there is any need for, and a

great loss is incurred thereby. To run a fancy as slow as possible to keep the main cylinder clear would seem the best plan to adopt, and then set it in hard, so as to wear the cylinder smooth, which, once accomplished, makes it easier, of course, for the fancy.

If the stock is very fine or short the speed may need increasing a little. The fancy pulley is generally so small as to cause too much speed, so that it is only necessary to lag the pulley with leather of varying thickness to reduce the velocity to any desired point. A plan of great benefit on difficult stock, which will keep the main cylinder in good order and prevent it from gumming, is to raise a tooth here and there, in the fancy, one-sixteenth or so higher than the rest. These so-called "stragglers" are of much benefit on short stock disposed to stick in the wire of sheets, and are of advantage on any kind of work.

As to what is the proper relative speed of the fancy and main cylinder depends, first, on the kind of clothing on both of them; and, second, on the condition of the material carded, besides

many other things; so we shall make no attempt to give any rules in the matter, merely saying that no fixed rules can be devised.

A rule that might answer perfectly on one lot of wool might be useless on the very next lot; not, perhaps, from any difference of quality, but because of difference in condition. If there were no fortuitous circumstances to contend with, a set of rules might be given adapted to the various grades of wool; but there are so many circumstances governing this matter that the best set of rules devisable must be almost nullified by the all but endless necessary exceptions.

For ascertaining and estimating the speeds of pulleys, cylinders, etc., tables are given at the end of this book; and further particulars as to the speed of different portions of a carding machine will be found in the remarks on "The speed of cards."

I would remark that the carder need not feel discouraged if he fails to succeed at first with a new fancy, especially if it be on a finisher, for the man is not born who can invariably make

one work perfectly at the first trial. Keep before your mind the principle that must govern your actions, namely, perfect truth and smoothness.

THE DOFFER.

A doffer *must* be sharp, it *must* be smooth, and *every* tooth should be up to its work.

The nearer a doffer approaches in diameter to the diameter of the main cylinder the better, because more resisting or carding surface is gained that way than is possible otherwise, and surface is what is wanted.

The shorter the material worked the larger the doffer should be, because that kind of stuff is more difficult to card, and therefore requires more carding; and more carding means more surface at every carding point.

Celestin Martin, of Verviers, Belgium, to whom we are indebted for many improvements in carding and spinning, tried to convince the English that their theory of large doffers was wrong; and he even went to the extreme of exhibiting a set of his cards at the London

Exhibition of 1871, with no doffers over 8.87 inches diameter. In order, however, to get through a fair amount of work he had recourse to a very novel and ingenious device by which the doffer should not move in one direction continually, but should move forward, say one inch; then back a half inch; and forward again one inch more, etc.; thus impaling one layer of fibre upon another. But the practical English carders laughed at it, for it was a fair admission that, in order to get sufficient carding power on his small doffer, he was obliged to cause its surface to be doubled, by alternate forward and reverse motions, the effect of which was to lay three successive layers, one superimposed upon the other; or, in other words, the doffer advanced one inch,— that was one deposit; it returned a half inch, that was a second; it advanced again one inch, and that made a third deposit. Martin himself said of this afterwards, "The wool of which the cloth or nap was formed, in combing three times under the action of the drum (main cylinder) before being lifted by the comb, was too much

combed by it. Its filaments were so arranged together in the direction of the working of the comber (doffer) and in the length of thread (slubbing) that this last was not only a carded thread, but a combed thread, which rendered it stiffer and harder to mill." After this he said, "I now construct this assortment with combers (doffers) 21.3 inches diameter."

I quote Martin, because when he was alive there was no better authority in Europe on carding and spinning than he, and also because he opposed the large doffer for years by all sorts of ingenious arguments, but finally came to making them of the largest size. The cards built by Martin at his works in Verviers were always well constructed, and in proper hands always performed well, because he was a thorough carder himself; but he was always changing them, and hardly any two cards which he made were alike. Martin was the first to use self-adjusting poppets, exactly as they are just beginning to be made in this country, and supposed to be a new invention. He also invented the composition cylinders, but they did

not prove successful. The strap divider was also his invention, and all others since produced are merely modifications of his ideas. His burring machine has never been excelled, if equalled, and his disc-grinder is worthy of being better known. Many devices for feeding both first, intermediate, and finisher cards were invented by him. His continuous spinner gave evidence of his remarkable ingenuity and originality. Two of the latter were exhibited at the International Exhibition, in Philadelphia, in 1876, as was a model of his "divider," of which we shall speak presently.

The "point" on a doffer should always be sharper, or keener, than the opposing point on the main cylinder, for these reasons: firstly, the doffer has to carry away the product from the main cylinder; secondly, the latter has an advantage in surface velocity much in excess of the doffer. Then there is the necessity of always keeping the machine throughout clear of accumulation, the burden of which falls on the doffer; all of which proves our position conclusively, that a doffer must have a keen, true,

and smooth point and surface, in order to adequately perform its difficult and various functions properly. Its "point" must needs be the superior of anything else in the carding machine. The main cylinder has another advantage, for its point is, or should be, kept continually in good working order through the friction of the teeth of the fancy, and the tendency is for its condition to improve rather than otherwise. With the doffer it is wholly the reverse, for everything is thrown or propelled against its points by the combined action of the main cylinder and fancy. Unless we provide a means to overcome the tendency of the points on the doffer to gradually and constantly diminish in their keenness, we may expect, before a great while, that bad work must ensue; and this brings us to consider a very important feature of a carding engine, but imperfectly understood among our carders; or, at any rate, if understood, very little appreciated, judging from its scant employment. We refer to what may appropriately be termed a conditioning roller, but known by the ludicrous name

of "tickler," or, in some parts, as a "dicky." It is a small roll placed over the doffer near the fancy, and driven at a slow speed. This roll, covered with card clothing of almost any kind so long as it is finer than the teeth of the doffer, is driven from the latter in one of two ways; that is, either in the same or in the opposite direction to the doffer. It should be of iron, or may be of wood, if very true, and about 3 inches diameter. Standards attached to the card-frame may be fixed to support it, or brackets attached to the "arches," or a continuation of the fancy brackets may answer. The clothing requires to point in the same direction as that on the doffer. If it is driven in the same direction as the doffer, its surface may travel slower than the latter, or faster; it makes but little difference so long as it is *not* too fast. If it is driven in the opposite direction, then its surface must necessarily go slower than the doffer. Whichever suits the carder best he can employ, so long as the difference between the surface velocity of the one does not exceed more than one-third that of the other, or thereabouts.

When properly applied it will always keep the doffer in excellent form, with its points clear, never allowing them to become filled to the level of their surfaces with fibres or dirt, and, these two objects gained, will facilitate the carding of the material in a very great degree. A doffer once sharpened, and then intelligently arranged, as we have described, will never need grinding again; and we will go further, by saying that to put an emery-wheel against a doffer so treated would spoil it in a measure, for its points would then be roughened and blunted. A doffer, after running for some time fixed as above, will feel to the touch, in one direction, like the pile on the finest velvet; but, in the other direction, as if full of the sharpest needles.

Smaller "ticklers" can be applied also to the ring doffers, and will be found of great benefit, especially on short stock, difficult to strip from the rings.

For fillet doffers the "tickler" may be covered with old fancy clothing, especially if the wire is fine with which the doffers are clothed, and

the fancy wire stiff and rather short in length, so it can be set that its teeth will work amongst those of the doffer with sufficient vigor to produce the result wished for. If your "tickler" "kicks," that is, throws out any of the fibres, then it is not fixed properly, or the relative speeds of the two are not right, and in that case just sit down and study your particular case, and find out where you are wrong, instead of condemning it.

Judging from the sales of the previous editions of this book, it is quite likely that the above remarks may be read outside of these States, where the arguments in favor of this appliance may seem the commonest of common-place information, and it may so appear to a few in this country; but there are so many to whom the information will be new that I have been careful to explain fully, for their benefit, what some others may already be familiar with.

In setting or adjusting doffers it is important to always remove the fancy, and see also that the worker belt is on; for if the latter is

neglected it may raise the doffer slightly in its bearing afterwards, and by so doing bring the doffer too close to the main cylinder and destroy the points of both. By taking the fancy out a clear view can be had, and the distance accurately gauged all the way across. The main cylinder should be turned into various positions as well as the doffer, and at each movement carefully gauged with a steel gauge, so as to be perfectly sure that when they are running they cannot touch.

A doffer of liberal dimensions, fixed as we have explained, and kept in good condition, readily receives the wool from the main cylinder, and may easily effect a saving in waste and flyings of 50 to 75 per cent. as compared to the usual plan of working.

WORKERS AND STRIPPERS.

Workers may be likened to doffers in regard to their functions in the carding operation, and all the points we have insisted on in the article on doffers may, with equal reason, be applied to workers. The larger their diameter the

better they will perform their duty. They must be kept *sharp*, *true*, and *smooth*.

Workers should be set in progression, beginning with the first one the farthest off, and ending with the last one the closest to, the main cylinder. As to the number of workers, we may say that there should always be as many as possible, and the number will depend on the size of the main cylinder, and position of the doffer, which should be set down low in the frame, in order to get all the workers possible. There should never be a cutting down of the doffer to admit more workers; that is contrary to our ideas of carding, for this reason: that by increasing the doffer but slightly we gain more surface contact with main cylinder than could be had by the addition of a worker, and conversely lose more by cutting down the doffer to gain a worker. Then we maintain that the position of a doffer and its large diameter as compared with a worker gives it at all times the preference if an increase of surface is to be made.

Various arrangements are in use for operating

workers, namely, by belts, chains, and ropes. We prefer the belts rather than the chains, but must have the pulleys covered with leather, else a belt is a source of continual trouble, owing to the very slow speed it must travel. The chains seldom drive the worker at a regular speed; they more often "go by jerks," leaving rows of wool along their surfaces corresponding to the links in the chains. Then it is a clumsy way at best.

The ropes are very neat, and of ample power to operate the workers if the grooves in the pulleys are of the right shape. All grooves of this kind should be constructed on the principle that the depth of the groove shall be greater than the width; then the ropes will find a bearing against the sides only of the grooves.

Strippers, being simply conveyers of the fibres from one cylinder to another, furnish us but little to discuss. They are usually 2½ to 3 inches diameter before being clothed, and on this account the teeth are spread apart more, by their being bent around so small a circle, and therefore great care should be used in

grinding them, or the teeth will be jammed, or bent out of shape. They do not need to be sharp, but should be smooth, and as true as it is possible to make them. For this reason they are generally made of iron, although the rest of the machine may be of wood. Sometimes they are placed on one side, and at other times on the opposite side, of the workers. The best side, however, is the one farthest from the fancy, so as to allow the wool to pass over the top of the worker, the latter revolving in the opposite direction to the main cylinder. The great majority of cards are so arranged, the exceptions being few and more notional than possessing any value.

The direction of rotation of the worker is sometimes reversed, so that they revolve in the same direction as the main cylinder, and in that case no wool is seen to pass over the worker, for the wool is no sooner lifted from the main cylinder than it is returned by the stripper. We fail to see anything gained by this proceeding; and after trying both plans we concluded to stick to the good old one, as first described,

in the belief that we attain a better distribution that way.

In many parts of Europe, but more particularly in England, it is a common practice to run the strippers close to the workers, so they rub together, and it is in this manner that the workers are always kept in good shape, and the "point" well maintained. The strippers, of course, lose their "point" by this proceeding; but by careful treatment they become very smooth, and that is the main thing. At any rate, they perform their part of the work in a satisfactory manner when so arranged, although in this country they are, as a rule, never allowed to touch; nor is it so necessary on good wool as it is on short stuff.

RING DOFFERS AND DIVIDERS.

We shall give to John Goulding, late of Worcester, Mass., full credit for the first invention of a combination of ring doffers with a condenser, and must refer the reader to the Appendix for a fuller account of Goulding and his other numerous inventions.

Before the introduction of rings, and the modern system of condensing, all carding engines consisted of a "scribbler" and a "carder," the latter so called because it made what was known as "cardings." The doffer of the carder, instead of having rings, was clothed with "sheets." These sheets were nailed on in such manner that there was left a vacant space between each sheet and the succeeding one. These spaces broke the continuity of the wool as it was combed off the doffer, and such portion of fibrous material as adhered to each sheet was called (after it was doffed and rolled up) a "carding."

The first rings which were employed to supersede the cardings were about 3 inches wide, and the originators of those rings never dreamed of doing anything further than still making cardings, but making them continuous, instead of in short lengths, the width of the carding machine.

Rings of this kind were invented before the date of Goulding's patent, which was granted December, 1826. Rings placed in wavy or zig-

zag lines around the doffer had also been tried; but there was nothing at all touching even the borders of our present system until the date of Goulding's patent.

The *two*-doffer system is peculiarly American, and, although it has been tried in every manufacturing country, in Europe it has invariably been abandoned, and the single doffer used instead.

There are many reasons for this state of things, but chiefly it is the inherent imperfection of the system which has caused its abandonment. We have already referred to these defects in the chapter on adjusting the cards, and it only remains to briefly examine into the causes for the variations in the product of the top and bottom doffers. The causes are mostly attributable to the fancy, which, being closer to the top doffer, projects thereon a varying quantity of fibres, which can in no case reach the bottom doffer. To neutralize this tendency the rings are always made of a narrower width for the top doffer than for the bottom one; but this is, at most, an unsatisfactory arrangement, for

with one kind of wool a certain difference in the width may be about right, while all wrong with another kind. Another plan, very generally adopted and very much opposed to good carding, is to set the top doffer further from the main cylinder than the bottom one; but this is not a remedy, as we have before explained; see "Setting and Adjusting."

There seems to be only one feasible way of making the one equivalent to the other, so far as regards the size and weight, and that is to run them at different velocities, the top one the fastest, including its complement of rubs and spool drum. The readiest way to do this is to have two pinions on the hub of the pulley which operates the doffers, instead of one only, as generally employed. One of these pinions is changeable, and operates the top doffer; the other may be fixed permanently to the hub of pulley, and it operates the bottom doffer. By having several changes of one tooth difference, easy of application, the speed of the top doffer can be altered as small an amount as desired at any time.

The result with both doffers set to the main cylinder alike will be that the top doffer will give off a greater length than the bottom one for the same weight, instead of greater weight for the same length, and by testing they can be brought nearer together than is possible otherwise, and may be spun together without any great difficulty, although, of course, they never can both be of the same condition, though the same in size; for we cannot neutralize the effect of the fibres thrown off by the fancy, which are always of a different character from those which are not thrown off.

Comparing this system with the one-doffer plan universal in Europe, and we must admit that in principle the latter is much superior, and we have no doubt that if the most perfect thread, or the greatest attainable length, must be got out of a given raw material, especially if the latter is of poor quality, then we shall have to look beyond the two-doffer arrangement, or be disappointed. But there are different arrangements of the single doffer, some of which answer very well for short wool, but not so

well for long wool as the two doffers would; for the reason that if all the rings are on one doffer the separation of the fibrous substance is more difficult, and there is greater liability of fibres crossing the very narrow division between the rings than is the case when every alternate ring is above or below the other, for then the separation is certain, whatever else takes place.

The two plans mostly in use for taking off the "ends," or "ropings," or "slubbings," abroad, is, for short wool, to take them all off at one point, and through a single set of rubs, dividing them alternately to top and bottom spool as they come through the rubs. This is known as the "single condenser." The double condenser plan consists in stripping every alternate ring below by means of a wipe roll, having rings fitted with alternate spaces. The latter allow each opposite slubbing to pass upwards, where all that are left may be taken off with a wipe roll made the same as bottom one, or a plain one might be used. Those stripped below pass through one set of rubs, and the rest through

another set above. This arrangement answers for longer wool, and is mostly used.

Whichever plan is adopted the rings are the same, that is, they are placed within about $\frac{3}{16}$ inch from each other, the space being filled with a narrow strip of leather, gutta-percha, papier-maché, or other substance, level with the surface of the teeth. The main cylinder cannot, of course, deposit any fibres on to these spaces, and whatever fibres the fancy may deposit on them have to pass the main cylinder before being stripped; and the latter, by its superior speed, wipes them off, so that they become pretty well separated.

In all these arrangements there is a certain amount of fibres left on the main cylinder, opposite the ring divisions. In order to distribute or change the positions of these fibres, so they will be taken up by the rings, several devices have been used; but the one at once the simplest, and most commonly used, is to arrange a worker so it will reciprocate back and forth for a short distance. The stripper may also move with the worker. By this it will be

readily seen that the fibres become transferred on the surface of the main cylinder, from every point opposite the divisions between the rings, to points opposite to the rings themselves. Sometimes two workers are caused to alternate in their reciprocations for the same object, but one answers every purpose.

Numberless devices have been tried for separating the wool into threads at the doffer, in order to dispense with rings altogether, or to render the division more perfect. Knives of thin steel have been inserted between the doffer and main cylinder, so as to enter into the teeth of both. Sometimes they are fixed to project upwards, sometimes downwards, and sometimes to partly envelop the doffer, and fixed to a bar in front. Sometimes the rings have lead between them, and sometimes thin rings of steel projecting beyond the surface of the teeth. Rings put on in wavy lines, and also put on rings of brass which have been caused to wabble sideways as they revolved, have been tried. Saw-toothed dividers, revolving shears, cutting-rolls, sectional combs, have all been

invented and reinvented time and time again. Every month or two we see an account of some new device; but find it old enough on examination, — a reinvention of an abandoned arrangement, perhaps a quarter of a century since.

Coming now to consider the most modern arrangement, and the one in our opinion which will eventually exclude all the others, and we find that Celestine Martin was the first to take a new departure, and invent a device which should separate the threads from a continuous film *after leaving the doffer.* This he called a "*continu*" or divider, and it was arranged to divide the fleece of fibres into as many threads as desired, allowing for double the number from the same width of card that could be obtained with rings. The doffer in Martin's system is entirely covered with filleting, and provided with a doffing-comb of the usual construction. In front of the doffer the divider is placed, and the sheet of wool is passed into it between two iron cylinders, with alternate solid rings and grooves, precisely the same in appearance as a pair of ring doffers placed one

above the other. The grooves are turned out of the solid metal, and are just of sufficient depth to take a leather band in each, so that the outer surface of the band, when inserted in the groove, shall be exactly level with the surface of the solid iron ring of the cylinder. The width of grooves and corresponding bands is determined by the number of threads required to be turned off, say 96 in 48 inches, although I have seen them turning off 120 in that width. The result of the band arrangement is, that when they are in their respective grooves in the top and bottom cylinders, and the latter are brought together in their ordinary position, viz., one above the other, then the two surfaces are level clear across with alternate rings of iron and of leather bands. Between the cylinders so arranged the sheet of wool is passed, and if nothing else took place the sheet of wool would come from the cylinder precisely as it entered. Instead of that, however, the position of the bands is changed on the side opposite to the entering of the wool in such a manner that each band before in a groove of the top cylinder is

carried down to the corresponding lower solid ring, and the one in the lower groove transferred to an upper solid ring, alternating thus all the way across. The wool in a thin film passing between the smooth surface of these two cylinders on one side is thus caught in alternate strips between each band and the iron ring of the cylinder and divided, every alternate thread passing upward, and the next downward, until they reach a point about opposite the centre of each cylinder, when the position of the straps is again changed, and the strips of wool, now perfectly divided, are wiped off the bands, and transferred into their respective rubbing devices, and thence to the spools, or bobbins.

It was found on some classes of work objectionable to have the rubbing motions so close together as this divider necessitated, for we have just said that the strips of wool were removed at a point opposite, or thereabouts, the centre of each cylinder, and this, unless the cylinders were very large, which is inadmissible, brought the rubs quite close and cramped, and

required them to be set at an angle, the top set running upwards, and the bottom set downwards. To obviate this a *pair* of straps were provided for each thread, and between them the strips of wool were caught substantially as described, and they conveyed the strips to the rubs, which in this case were of the usual horizontal pattern. This is the prevailing style of divider now extensively used in Belgium.

The difficulties with both these arrangements were confined to the leather straps, each of which must be of the same exact width throughout; also of the same thickness and of the same consistency, so as not to stretch unequally, and, moreover, they must all be maintained at the same tension. If variations occurred in the straps they affected the threads, as there were separate straps to each thread. But the difficulties were never of much moment, not enough to prevent the rapid introduction of the machine into the mills of Belgium and France. Two or three were sent to this country, and are now running; a considerable number were built in England, but it never won the affections of the

English carders, who claimed that the long fibres were either broken, or were pulled out of the mass, and therefore made thin places in the threads. That there must be more prejudice than practical difficulty on this point we have ample evidence. It is no doubt true that on extra long, coarse wool some hairs will be pulled out; but wool of this kind generally goes into work where a fibre or two is of no consequence, and the fact of their having superseded very largely the ring doffers, of whatever kind, in Belgium, shows conclusively that they have practical advantages.

To overcome the objections of the straps a new arrangement has recently been brought out by Bolette, of Pepinster, who uses only one strap to divide the whole of the threads; and he claims that, if the width or other condition varies, the defect becomes equally distributed amongst all the threads, and is therefore lost.

Whichever plan is used, the principle is the same; we see a doffer of large size, 30 to 40 inches in diameter, having its *whole surface* covered with fillet (points), which means more

carding surface than can ever be got with rings, whatever their arrangement may be. The consequence of this is, that more threads can be made, and this means either more length or more weight, during an equal interval of time, than is possible with rings. The wool being deposited on to the doffer equally over its whole surface, and afterwards divided from a homogeneous film or sheet of equal consistence, it follows that a more regular and more perfect thread can be gotten this way than can ever be hoped for with rings.

Comparing the work of these dividers with rings, either for length or weight, settles their claim to ultimately become universal. Martin exhibited, at the Vienna Exhibition, a divider delivering 122 threads, including the side threads, from a sheet of wool 3 feet 9½ inches wide; so that there were 120 good threads: 60 of these passed between one set of rubs, and 60 between the other. As they came out, every alternate thread from one lot of 60 was passed up and down, and the same with the other lot, to their respective spools, or bobbins, making

in all 4 spools for the spinning mule, each containing 30 good threads. There are any number running on work so low as 1 run, or 1,600 yards per lb., and plenty on fine work running, with satisfaction, at 20,000 yards per lb.

To compare this principle of dividing with that produced by double-ring doffers would be ridiculous, for it is as two to one in favor of sheet dividing, as regards either length or quantity of output; and as regards quality, regularity in size, and condition, it is all in favor of the Belgian system. The superiority of that system is so manifest that we again reiterate our opinion of its speedy adoption, and the removal of the little, but greatly magnified, difficulties at present supposed to exist.

CONDENSERS.

These appliances have undergone as many modifications as have the doffers and other parts of the carding engine, but we need discuss but two or three sorts which have at different periods gone into use.

Perhaps the kind first devised was the *Tube*

Condenser, once largely used in this country; in fact exclusively so until the rub motion was invented. There are some tubes still running in many of the older mills, mostly on such work as flannels, or other goods requiring a woolly effect. The tube, by its revolutions, or centrifugal effect on the slubbing, makes a hairy-looking thread, full of fibre as compared with the work when rubbed, for in the latter case the fibres are pressed and rolled around the body of the thread.

When the rub motion first came into use, it consisted of 1 large roller, about 7 inches diameter, with 2, and afterwards 3, smaller rollers on top, about 2 inches diameter.

The latter were fixed at one end to a head, which by means of a rock shaft were caused to reciprocate upon the surface of the larger roller. The whole were covered with leather and made to revolve, thus conveying the slubbing between them, while at the same time it was rubbed and condensed.

Then the five-roll rub, all of equal diameter (about $2\frac{1}{2}$ inches), came out, having three rolls

at the bottom and two on top, lying between each pair of the others, and to each set a vibratory movement was applied in such shape, that, as one set moved to the right the others moved to the left, and *vice versa*. This was the invention of an Englishman, who was unfortunate in allowing himself to be humbugged out of it for the sum of $25, we are informed. The improvements since then have altogether consisted of changes in the methods of obtaining the reciprocating movements in the form of the wearing parts, and additions to the number of rolls, which are now made up to 15.

The rolls are geared in pairs, that is to say, a top and bottom one are connected by a pair of gears at one end; and the next pair are connected to the first by an intermediate, and so on. Each pair, however, are driven at a faster rate as they extend farther from the doffer; the gears on the bottom rolls being proportionately less in diameter and number of teeth as each pair succeeds the other.

The result is, that the front rolls from which the slubbings are delivered to the spools, or

bobbins, revolve at a rate about one-third faster than the rolls which first receive the wool near the doffer. From this it follows that a "draft" is produced during the progress of the wool through these rolls; the amount of such draft, or elongation, depending on the number of rolls, or the relative increase of speed of each pair. It is well known that this style of condenser is in use in every woollen mill in America, and that it has crowded all others out.

In Europe there are none, that is to say practically, of this style of condenser. The European differs from the American condenser, which we have described, in having leather aprons, one above the other, instead of rolls. Each of these aprons is stretched over a pair of rolls, and neatly joined (sewed) together, with provisions for tightening them should they require it, and also means provided for keeping them straight and parallel at the ends. The apron rolls revolve by means of gears at one end, and are caused to reciprocate by being fixed to a headstock at their other ends. The slivers of wool passing between a pair of these

aprons are thus both carried along, and rolled, or rubbed. It is evident that no draft or stretch can take place in the filaments by the use of this condenser.

The aprons are of various widths, from 14 to 20 inches, and the reciprocating movements are of various kinds; but the machine, as we have described it, is as universal in Europe as the condenser with rolls is in the United States.

Now, when there is such a wide difference as this in the modes of conducting a mechanical operation, practised on such a large scale, each plan involving a whole hemisphere of manufacturers, each unanimously practising the one plan to the exclusion of the other, and not from ignorance of it, we are constrained to look into all the facts and inquire into the causes. In order to do so intelligently, we have, first of all, to note the difference in the materials, as a rule, which are carded in this country and abroad. Here we have wool not so largely mixed with short materials, and the wool itself also of a longer and generally coarser and stronger nature than is mostly used in Europe. The

roll condenser, while it may not act injuriously on such materials, or seriously affect the regular continuity of fairly good and long wools, cannot be said to be of any value on short stuff, or on fine work requiring a superior thread of the utmost regularity. This is all we can say in favor of it, and we consider it useless for the best of work, and of no advantage on work such as we have mentioned, of long wool, as the succession of jerks is a bad feature on any kind. It may be argued that each succeeding pair of rolls only take up the slack. Well, we are quite willing to allow that point, but ask, how is the slack produced? It is thus produced: between the "bite" of one pair and the next pair there is a distance of, say, from 2 to 3 inches, it is not material, and the slubbings are held at these two points. But the forward point is travelling at a rate faster, than the rear point, and between these two a top roll is interposed. Now, this top roll must be geared to and move with one or the other of these bottom rolls, each of which is revolving at a *different* rate. It must be impossible for the surface of the top roll to

accommodate itself to the surface velocities of these bottom rolls; therefore the wool is stretched. Of course these rolls could be geared so the gain in their speed would not affect the regularity of the stubbings, but in that case if one of the latter should happen to get broken then the new end would not come through the rolls, but would wind around the first or second one, probably; therefore there must be a gain, and consequently a stretch in the wool, which we maintain is wrong in principle. As before said, the effect is of less consequence on good stock, but can never be as successful on short stuff as the apron condenser. In every other respect we prefer the roll condenser; it is neat, takes but little room, and is convenient.

The apron condenser for fine, delicate work, or very short stock, cannot be excelled; in fact, nothing can equal it where the utmost is being got out of the material that it is capable of yielding. The fact of its taking up more room, or being somewhat more clumsy, as at present constructed, or requiring perhaps, for the same reason, more power, does not alter the case, as

we look upon them as side issues; for in this book we are solely discussing the best present means for securing the best of work.

ON THE SPEED OF CARDING CYLINDERS.

The speed of main cylinders and doffers need only concern us, as the other parts are not important in woollen carding, except the fancy, and we have already said all that is deemed necessary in relation to its speed.

Main cylinders, as a rule, are driven altogether too fast, and I have never yet found an intelligent reason given therefor. It seems as if the constructors of carding machines built them to their own notion, with pulleys of a standard size to suit their own convenience, and then the machines are set up in mills without any particular regard to speed of shafts, or size of driving pulleys. We have found the cards in different rooms of the same mill running at speeds varying 30 per cent., and have often seen them on the same floor running from 90 to 120; and sometimes not two sets at the same speed. In one mill we have seen cards driven

at the rate of 140 turns per minute; in another mill, on the same kind of work, at 90 turns per minute, — all of which shows, we think, that there is no correct theory regarding the speed of cards. I have often been told in reply to the query, "Why do you run your main cylinder so fast?" — "Oh! we must get off the production, you know." And there is no doubt that many entertain the idea that high speed of main cylinder is necessary to get off the production; but it often happens that high velocity means low production.

A good rule to follow is, when the stock becomes shorter, reduce the speed proportionally. From our experiments we should recommend that no main cylinder revolve faster than 90 turns per minute, and for excessively short materials not over 60, for cylinders varying in diameter from, say, $3\frac{1}{2}$ to 4 feet; or, to be more precise, we should say a surface speed for good wool of not more than 1,050 feet per minute, and for shoddy, or other very short materials, about 700 feet per minute. On all ordinary work we think that 1,000 feet per minute

is ample surface speed for a main cylinder, and we should want it lower rather than higher. A 4-foot cylinder, at 120 revolutions, would propel the fancy at say 1,750 to 1,800 surface feet per minute. Is it any wonder, then, with such a velocity, the stuff flies all over the place, and we can see as much fibre in the air, at any time, as there is in the card? But the most ludicrous thing of all is to see such a speed on hosiery work, where the stock consists of from 50 to 90 per cent. of cotton. Go into a card-room of this kind, and it is dreadful; for the cotton is everywhere except in the card, and it is a common thing to employ a young person to do nothing but sweep up the flyings. Now, if any good end were gained by this high speed, we could be reconciled, but there is not the least; it is, in truth, nothing but a loss from beginning to end.

With the DOFFER fresh things enter into the calculation, and, although we always desire to get the speed down as low as possible, still we must not go too far in that direction, seeing that it is the speed of the doffer which governs

the quantity of material carded in a given time. The only way to turn off the production, and at the same time provide a slower doffer surface, is by using a doffer of liberal dimensions, as advocated in the article on "Doffers." With a doffer of 16 or 18 inches diameter we will have nothing to do; for we cannot, with a diameter so small, accomplish the best work, nor yet the most of it. 30 inches diameter is the smallest we can get along with, and would have it larger rather than otherwise, say 36 or 40 inches diameter, for the best of work. It is easy to understand that a 16-inch doffer would have to make two revolutions to turn off the same length of sliver as a 32-inch doffer would turn off at one revolution.

Such are the principles which must be observed in relation to the speed of the doffers; and further than describing them we cannot go, as every one must govern his speed to conform to the work he may have in hand. If the work is clean, open stuff, or containing much cotton, or for any other reason not requiring a great deal of carding, then the doffers may run at

almost any speed. But if the utmost care is necessary, and the greatest length is being got out of the material, then it becomes imperative to run the surface of the doffer more slowly.

The idea which every one should particularly keep in mind is this, — that the speed of the doffer governs the rate at which the wool shall travel through the carding engine. This fact at once makes it clear, that for work requiring plenty of carding we must necessarily keep it in the card under the action of the carding process longer than if it required less carding, and in order to do this the doffer must run slower.

It becomes a difficult matter to accomplish the above, and at the same time get out the utmost quantity of work, for slow and thorough carding means low production. It is these considerations which have caused the carding engines, in localities where stuff exceedingly difficult to card is used, to increase in width in a few years' time from 40 to 72 inches. By that means they have obtained the best carding and most of it.

There is as much diversity in the speed of

FEED–ROLLS as there is in speed of other parts of a carding engine ; but we have always found that, with a slow speed, and good, thick, compact feed, with the rolls and taker-in free from dirt and in good trim, a great part of the purely straightening and combing process can be done at this, the incipient stage of carding. No more important portion of the machine can be found ; for if the fibres are straightened out at the beginning, and so presented to the succeeding cylinders, there must follow the best results. How often it is otherwise every carder knows for himself, and we see by far the greater number utterly neglecting these vitally useful members. They are left to care for themselves until gummed up, and there is not the semblance of a tooth to be seen. A moment's reflection ought to convince any one how hopeless it must be to expect good results to follow such carelessness.

CLEANING THE CARDS.

The remarks on this subject will be few, but nevertheless useful, it is hoped.

It is quite a common practice to clean a card

all through at regular intervals, or when the main cylinder appears dirty. In this way much needless waste is made, and no particular advantage gained. On any kind of stock the main cylinder gets dirty first, and as it would not be beneficial to clean it without cleaning the doffer also (for it is important as before stated to keep the doffer clean), then all that is necessary is to clean those two at one time. By the time they require cleaning again the machine can be cleaned all through. Of course the comb will be cleaned each time.

The writer has followed this plan for years on all kinds of stock, with a considerable saving of waste and time; but he manages to arrange it so as not to clean more than one machine of the set clear through at one time, for the reason that when, say, first and second breakers are cleaned throughout, the strippers, etc., will for a time accumulate some fibre, causing more or less fine rovings to be made immediately afterwards; but if first breaker be cleaned all through, and second breaker only cylinder and doffer, such a result will not be so likely to happen.

I clean the first breaker six times a week alternately all through, and cylinder and doffer; that is to say, three times all through, and three times cylinder and doffer, each week. Second breaker is cleaned each second day, alternately, all through, and then cylinder and doffer. Finisher twice a week, once all through, once cylinder and doffers.

I merely give this as an item; it is no rule to go by, as, if the stock is prepared for the cards in the best manner, and as thoroughly freed from foreign substances as possible, less cleaning of the cards will be required than if the reverse is the case. It may be said, however, that everything foreign to the wool has to be removed previous to carding, or will have to be carded out, and it is immensely cheaper to remove every kind of dirt before carding.

It is also advisable to ignore the use of the cleaning-comb as much as possible, using the hand-card in preference, where it can be used effectually. The objectionable feature of the comb is, that its teeth are rigid, and consequently injure the clothing to a great extent when too

freely used. If the comb is not at a proper angle the mischief is still worse, as also if it is too fine for the wire. A comb with 18 teeth per inch will injure card clothing less than a finer one.

Never put a comb on a doffer, for every tooth is too valuable to risk such treatment, even in the most careful hand; each tooth must be up to its work.

Strippers may be cleaned when they begin to gum over, and may run a week to a month or two, depending on their condition and the cleanliness of the wool.

Cards need cleaning in proportion to the care and judgment used in putting them into good condition to run clear. If wool is not clean to begin with, the cards will have to suffer, for the dirt will not go through with the wool. It behooves every carder, therefore, to insist on having the wool thoroughly clean; for it will neither pay him nor his employer to card dirt, besides injuring the clothing, and losing the time necessary to remove such dirt. Clean oil, free from gummy matter, should be used on

wool. Oils that are composed of a mixture of animal and mineral oils are the best, if of good quality, and are cheaper. The oleaginous substance, whatever it is, should be evenly distributed throughout the batch.

I think it is an error to clean cards by established rule; and it entails one of two evils, — either they are in whole or in part cleaned oftener than necessary, thereby making unnecessary waste; or they are not cleaned as often as they should be, to get off the best work and most of it. Nor can a mean be struck between these two extremes, because the time depends on the stock in hand. Therefore I think the carder ought to look his cards over and point out such as he wants cleaned, designating the parts. This he might do twice a day, or at any other regular intervals, not too far apart; and by so doing it might be possible to save a large percentage of waste, and also avoid any risk of the machines running longer than they should without being cleaned.

Every time the cards are cleaned, wipe out of the journals and poppets every particle of

wool or dirty grease; this will cause your journals to wear true and smooth. If neglected they will wear in ridges, and cause much trouble, as it is impossible to do good work on some cards that have been slighted in this particular.

ELECTRICITY IN THE CARD-ROOM.

Of all the cares and trials of a carder's life perhaps the one most mortifying is this electrical phenomenon. To enter the card-room on a clear, dry, frosty morning in winter, or in the spring when a dry cutting wind is blowing, and see the fibres sticking and flying hither and thither, with "ends" out more or less on every condenser in the room, and apparently impossible to ever again get them to keep in place, is, to say the least, a tantalizing affair. Carders are not supposed to know a great deal about electricity, and generally the extent of their knowledge of it consists in sprinkling water on the rubs, or allowing steam to escape from a pipe provided for the purpose, and knowing that the effect is remedial for the time being. *Why* such an effect takes place, or the where-

fore of this invisible demon of electricity, are alike subjects utterly beyond their ken. If it was a thing that could be fixed with a wrench, or even if it could be seen, then they could tackle it; but, as it is, it proves a veritable imp of darkness and mischief.

It may be remarked, that, so far as we know, it is in America only that carders have this trouble; and it is owing to the dry climate that such is the case, and not a peculiarity of the wool, as many suppose. In Europe they rarely or never see any manifestations of it in their mills, and we remember a story of an American gentleman who had lived on the borders of one of the New York lakes, where electrical conditions of the atmosphere were so strong that it was easy by rubbing the foot on the carpet of a room to draw a spark from the fingers sufficient to light a gas-jet. He, being on the continent, related this to some friends, who doubted the story, and he declared it was the easiest thing in the world, as he would show them; but judge of his surprise, when the gas refused to light in spite of his most vigorous rubbing,

much to the amusement of his friends. Electricians have often to keep heated irons around their apparatus when conducting their experiments in Europe, on account of the humidity of the atmosphere; for there is no greater obstacle than dampness to the exhibition of electrical effects.

We shall try to explain the fundamental phenomenon of electricity, and hope to make it plain enough to be better understood in regard to its application in carding.

If a tube of glass be made very dry, and then rubbed with a dry silk handkerchief, the tube will have acquired the property of attracting small bits of paper, straw, and the like; the vigor with which they will be attracted and repelled depending on the amount of friction to which the tube has been subjected. The tube has then become charged with what is termed *electricity*, and we say it has become electrified. Only that portion of the tube, however, to which the friction has been applied, possesses this power of attraction; it has not diffused itself throughout the tube, therefore

it (glass) is termed a *non-conductor* of electricity.

If we take a metal bar, say iron, and subject it to friction while being held in the hand, it will not be so effected, because, the human body being a good conductor as well as the iron bar, the electricity will pass through the body into the earth. But if the bar is held in a tube of glass, and then rubbed, the phenomenon will be manifested, because it is then *insulated* through the non-conductibility of the glass. The electricity will, however, have diffused itself throughout the bar, and it will be manifested at the opposite end to that subjected to the friction. Therefore is iron termed a *conductor* of electricity.

If a list of, say 30, of the worst conductors were arranged in succession, in proportion to their lack of conducting power, then wool would come about in the middle of the list,—after silk, which is a worse conductor than wool. Non-conductors are often termed insulators, and air, when very dry, is an excellent insulator,—dampness, however, changing it

into a conductor, as before explained. This shows us plainly why, in damp weather, we have no trouble in the card-room with electricity ; it is conveyed away by the atmosphere as fast as produced.

A dry, cold atmosphere is in the best form as an insulator or non-conductor : therefore do we on such days have trouble with the slubbings flying every way, clinging to the iron frame-work of the machinery, or to the person when near enough, or any other conductor of the electric fluid.

It is clearly evident, from the foregoing, that it is *static* electricity, or that kind produced by friction, to be more plain, which is the source of difficulty, and from this it follows that the radical cure is to reduce the friction and moisten the atmosphere.

So long as the wool remains in a more or less bulky form the phenomenon is not manifested, nor does it have to undergo such excessive friction until it is brought in contact with the rubs of the condenser, when, being at the same time divided into numerous fine filaments,

it becomes overpowered by the electrical influence.

Another reason why the generating power becomes accelerated in cold weather arises from the fact that the oil is to a certain extent congealed in, and fails to effectually lubricate, the wool fibres; that the greasy rub-rolls are dry and rough, in the best condition for producing increased friction. The wool is also less elastic, supple, and altogether more liable to be excited by peculiar electrical conditions of the atmosphere in cold than in warm weather. These causes combine to give the carder much annoyance, unless they are well understood and the remedy intelligently applied. From the nature of the material worked, and the influences pointed out, it must be evident that the only remedy is to reduce all friction to a minimum, and so remove the exciting cause. It has often been observed, that, to sprinkle a little oil or water on the condenser rubs, even when the rovings are flying off in every direction, the trouble ends at once; but this is only temporary in its effects, which proves our posi-

tion, that friction is the generating cause; for although, in lubricating or dampening the rubs with either oil or water, there is temporary relief, it only lasts until the water has evaporated, or the oil has passed off with the rovings, when it returns as bad as ever, because the friction is then increased to the same point as before the counteracting agents were applied.

When, therefore, the electricity begins to annoy you, I would advise the following plan: Take out all the rub-rolls and scrape off the grease from each, afterwards rubbing with a clean oily rag to smoothen any roughness. Replace when clean and smooth, and set them apart one-sixteenth of an inch, or at any rate so as not to touch in any part. Use a gauge, and set each end of each pair alike, commencing with the small stripper or wiper.

The roving does not require as much rubbing in cold as in warm weather, and the less it is rubbed the better, provided it comes off the spools well in spinning. Sprinkle a little oil on the side-drawings, at the finisher feed-rolls, previous to starting up, after treating the rubs

as described, which will in passing through further smooth them of any roughness that may have arisen from the scraping.

The trouble can also, in some cases, be immediately stopped by shortening the stroke of the eccentrics; but neither of these plans will entirely remedy the evil when considerable grease has accumulated on the rubs; the only thing to do in that case is to thoroughly cleanse them and make a new beginning. There is no need to go to extremes in setting them apart, so as to leave the rovings soft and flabby; the idea is to simply roll the rovings between the rubs without pressure, and this is all that is necessary under any conditions.

It may as well be stated here that the rubs are not intended to remedy defective carding, by attempting to rub inequalities out of uneven roving; they are there for the sole purpose of giving sufficient consistency to fine threads of wool, to enable them the more readily to unwind from each other in the spinning process; and all additional rubbing is unnecessary and mischievous. As a guide to others, the writer

will mention that he has carded the finest quality of merino wool for fine flannels, etc., in a room where for days together the temperature was not higher than 38° Fah., and this was done without any device for neutralizing electricity, as none manifested itself. Any one can do the same, in any kind of weather, by making intelligent use of the hints here given.

Among the devices which have been tried as agents for neutralizing card-room electricity we may mention, that fine wire has been wrapped around the front condenser-roll, wire of copper, of brass, tinned wire, iron wire copper plated, steel wire, and annealed wire; and sometimes both front rolls have been covered. Rolls have been tried made of zinc, tin, copper, wood, glass, and hollow iron rolls containing steam. Copper rolls set in front of the ordinary rubs are often employed, and are sometimes heated with steam; sometimes they are perforated, and are both made to revolve and to remain stationary. Wires stretched across for the rovings to touch, and then run into vessels of water, have often been recommended; and we have seen a

patented institution similar to a lightning-conductor applied with as many points as there are slubbings, and connected with the metal conductor, which ran into water, or into the ground. Steam pipes have been applied both to the rubs, and independent of them, and to the feed-rolls, breasts, and leaders-in. The rubs have also been coated with various substances, as flour, ashes, and the like; so that there is no lack of devices to select from, and, what is better, they are all sure cures, at once and forever, etc., etc.

As an example of one of the above forms we will relate the contents of a letter, which gives a sure cure for electricity, as found in America, and then, for comparison, another cure for the evil as found in Germany, which is also taken from a letter. The American letter instructs as follows: —

"Take two wooden strips and tack them to the finisher frame, three inches from the rub-roll, one on each side, and saw two slots in each just opposite roving. Then take two bars out of the loom harness, place them in the slots on the underside of both top and bottom roving,

letting the roving just touch them. Take a common small wire and loop it around each bar at one side of the card-frame; let the wire be within one inch of the roving; let the lower end of the wire be six or eight inches long; lay a piece of iron on the card frame, bend the end of the wire so that it will be within one-eighth of an inch of the piece of iron, and you will have but little trouble with electricity. Carders, try it once."— *Industrial Record, New York.*

In Germany they go about it thus: —

"The manufacturer in question found that during the process of carding his wool got so electrified that it would not follow the narrow straps which in many continental condensers take the threads off the doffer. After careful observations it was found that the cause lay in the material used for greasing the wool. When the oil was mixed with water and spirits of ammonia it became perceptibly electric, especially with each change of the weather, and became such a nuisance that the spinning operation was seriously inconvenienced. This, however, only occurred with fine wool, which had been

shorn unwashed, and then had been washed in a soda bath. Since the ammonia has been replaced by soda the inconvenience has almost disappeared, and is only felt with great changes of weather." — *Deutsche Wollengewerbe.*

"Our contemporary states the facts, but does not offer an explanation. That electricity was generated through the application of ammonia cannot be disputed, and the cause of the phenomenon evidently lies here." — *Textile Manufacturer, Manchester.*

It is a trite old saying that "too many cooks spoil the broth."

THE APPERLEY FEED.

As there are probably some 3,000 of these feeds in operation in the United States, and as difficulties sometimes arise with them, we will give a few plain directions for their management. We shall suppose that the feed is applied to a finisher card, for which purpose it is the best means known for feeding a *side-drawing* or rope; besides this it is handy, takes up less room than a lap feed, does not obstruct the

light, and it is *continuous*, — a virtue compensating for many of its defects.

At first sight this machine seems the embodiment of simplicity, and so in itself it is; but the conditions under which it works are such as to demand both judgment and care, so that it will be found no easy matter to go straight along at first. If a carder is called upon to start a set of these machines who may have had no previous experience with them, the first thing he will have to do will be to equalize the speeds of the several cards and feeders so that all will run in unison. This will require, as before stated, some pains and effort.

The first step looking to this end is to examine the driving-belt of each card, as well as the belts operating the feeder, licker-in, and tumbler, to be quite sure there is no slipping. All pulleys connected with the feeder should be covered with leather at the outset, which will save much future annoyance. This done, start up the second breaker and finisher; and if the latter picks up too fast, two remedies are at hand, — either to speed up second breaker dof-

fer, or reduce speed of feeder by means of the change-gears furnished for that purpose, or by building up the pulleys with leather. If, however, the feeder picks up too slow, it is only necessary to speed it up until both run in unison. If the wool lies too wide or too narrow on the finisher feed, it can easily be regulated at either one or both sides, as may be necessary. The feed should be a half inch short of the width of the card to prevent the wool overhanging the workers and wrapping around the stripper ends. The feed-table should travel at such a speed that the alternate rows of side drawing will remain regular and even, without one strand crowding over or under another. When the proper speed is attained, the strands will lie beautifully smooth and compact.

The finisher will need an extra ring on each doffer to take off the side thread, which must be re-fed on the first breaker as fast as made. This has often been objected to, as one of the defects charged against this machine; but it should be remembered that all machine feeds require it, whatever the type, and that those

threads are the most objectionable, and really ought to be thrown out to make good work, however the feeding is performed; for they have always been a prolific cause of poor yarn, and to this source can generally be traced "cockled" goods, which mill irregularly from inequalities in the yarn, arising from side threads getting mixed with the good threads. The gauge stick, previously described in the article on "Clothing with Rings," will be divided with one extra space at each end, for the top and bottom side threads, in addition to the spaces there spoken of, but in other respects the same. A ring of same width as the bottom may be put on outside of the top doffer, to take off the side thread, for it is better to have a wide ring so as to produce a good solid thread, under slightly varying conditions of feed. The side threads are best taken off by having a pulley attached to each end of upper spool drum-shaft 4 inches across the face, and same diameter as spool drum. A short spool is placed on each of these and kept in position by a small stand, which is bolted to the latter, one at each side, in pre-

cisely the same manner as the larger spools are held.

The small traversing rolls on the self-feeder, through which the side-drawings pass on to the feed-apron, need some attention, such as taking out the pins, cleaning out any fibres that may have accumulated, and must be kept oiled, so as to revolve freely. The flat plate against the edge of which these rolls revolve should be fixed at such a height that the wool may just squeeze through, but not so tight as to retard the side-drawings.

Retention bands of Belgian pattern, diamond point, 4 inches wide, are now furnished for the outside aprons, which serve the purpose of holding the doublings in position (in connection with the narrow spiked straps above) much better than the worsted aprons otherwise used. These belts are of especial benefit, for the reason that they pretty effectually hold the drawings from contracting, when released by the drop levers. The teeth are short and without bend, so that they readily part company with the wool on arrival at the feed-rolls.

It must be borne in mind that altering the speed of feed-rolls on finisher does not affect the size of roping; when such alteration is needed, it must be done at the second breaker, unless it also is fed with the Apperley, and in that case the alteration would have to be made at the first breaker, by either making the feed go faster or slower, or by increasing or diminishing the weight of the feed.

There is always a tendency for the narrow end of the Apperley to be the heaviest when the drawing is lifted from the floor. This is on account of the difference in the strain, between being carried in one direction or the other, with or against the angle of the feed, while the drawing is under strain; and in only one way can it be overcome, and that is by carrying it overhead, where the strain, if any, is equal, and the liability to break dispensed with.

Feed-rolls, licker-in, and tumbler must be maintained in faultless order to obtain the best results from the self-feeder; and we have already, in a former page, laid particular stress on this point; and, if the directions there given

are strictly followed, you will be enabled at less than one-half the trouble to make better work than ever before.

If the feed-rolls are allowed to get full of wool and grease it is no use to expect the self-feeder to work well; the wool will be drawn from between the feed-rolls in a diagonal direction, adding a surplus to one side by thus robbing the other, the result of which on a finisher can easily be seen. It is common to neglect these parts where the old spool-racks are used, and it is not so productive of evil results; but there must be no negligence if the feeder is used, for on this in a great measure depends success or failure. No matter how fed, it does not pay to neglect those parts, as the work can be and is vastly improved by care in this particular.

APPENDIX.

Carding in the Fifteenth Century.

APPENDIX.

CHAPTER I.

USEFUL INFORMATION, TABLES, ETC.

SPONTANEOUS COMBUSTION. — The combustibility of oils is a question for serious consideration, and ought to be a governing element in their selection.

The experiments of J. J. Coleman, of Glasgow, who has examined into this question, correspond with those of Mr. Gellatly, and other investigators, as to the time which ensues for a handful of cotton waste to spontaneously ignite when imbued with various oils and placed in an air-bath at 130° to 200° F. Boiled linseed oil required 1¼ hours; lard oil, 4 hours; raw linseed oil, 4 hours; olive oil, 6 hours; and refined rape, 9 hours. These experiments also demonstrated that a mixture of 20 per cent. of mineral oil retarded combustion, and with 50 per cent. it was *entirely prevented*.

Spontaneous combustion has proved a prolific cause of the destruction of many woollen mills which might have been avoided with reasonable care, and a fuller knowledge of the subject. It is the *duty* of every carder to understand the nature of spontaneous combustion, that he may thereby know the danger, and how to avoid it.

Spontaneous fires result about as follows: the oily waste absorbs and condenses the air within its pores, oxidation is at once started, and the temperature becomes elevated with

more or less rapidity, by which the process of oxidation is accelerated, and this operation continues, with constantly increasing energy, until at length the mass is inflamed.

If the mass is damp all these effects are aggravated, and the danger becomes far greater of immediate destruction. The low conducting power of such masses, especially when packed or confined, greatly facilitates the combustion, by preventing the escape of the heat thus generated; and, given these conditions, spontaneous ignition is as certain as the firing of gunpowder with a spark. The cask of gunpowder, so instinctively dreaded, will not explode till the spark is applied. The pile of oily waste, harmless to all outward appearance, but slowly and surely taking from the oxygen of the air the means for its own combustion, accumulates within itself a silent volcano, which most likely may burst forth in the dead of night, itself lighting the conflagration, when managers and operatives are locked in slumber.

Some years ago the writer happened into a Western mill and noticed a large mass of greasy waste, the leavings of the previous seasons of roll-carding. In those mills an extensive trading is done with the farmers from the surrounding country, who bring to the factory bundles of wool, varying in weight from 10 lbs. to 100 lbs., and also grease of some sort to put on the wool. This grease often consists of rancid butter, or lard burnt or discolored in the "rendering," and therefore unfit for domestic purposes. The carder puts as much of this grease on the wool as his conscience will allow, so as to return nearly the same weight of carded as he received of raw wool from the farmer; and not unfrequently the carded wool weighs the most, notwithstanding

the loss in passing through the cards; but in that case the weight is balanced by abstracting a portion of the innocent farmer's property to make both ends meet and to enrich the benevolent carder. Roll-carding simply consists in passing the wool through a narrow card, generally 24 inches wide, and sometimes having two main cylinders and doffers. At the end it is taken off by a comb; but, in order to get the rolls separate, the doffer is clothed with sheets having a space between each. The wool then drops into a hollow semicircular dish, in which a drum revolves, and the wool dropping from the comb falls between the drum and the concave shell, where, following the travel of the drum, it becomes rolled, until the exit is reached, when each roll drops into a receiver, and is finally gathered together in bunches, and delivered to the farmer. The latter pays a fixed price per lb., and his daughters, assisted by the "old woman," spend their winter evenings spinning the rolls into yarn by the aid of the traditional spinning-wheel.

It is at once perceived that the waste arising from these conditions is of a kind well suited for spontaneous combustion. The pile referred to was near the windows in the upper story, and to all appearances free from every sign of combustion. The writer, however, thrust his bare arm as far into the mass as possible, and dictinctly felt the heat. This was reported to one of the proprietors at once, and he was advised to lose no time in getting it out of the mill building; but he laughed at the idea, said it all had been "dusted," and the heat was no evidence of fire, as he had often had waste hotter than that, and never had a fire in all his experience; didn't believe you could set it on fire if

you tried; said it was too wet to burn, as the windows leaked, and the snow and water had beat in during the winter and in rainy weather. Neither argument nor persuasion availed, until on a Sunday, about ten days after the occurrence referred to, the mill was entirely destroyed while the gentleman was calmly listening to a discourse from his pastor. To him the experience came too late, as it has to many others, and he remarked that if he ever got started again he would not allow a pound of waste to accumulate from one day to another in the mill, no matter if it had been dusted.

The only safe plan is to have a regular system of removing all accumulation of greasy waste daily to an isolated building (if the waste is not used as fast as made), and there exposed as much as possible to the atmosphere.

If, however, mineral oils are exclusively used, there is no danger; or if such oils are used as an admixture with animal or vegetable oils to the extent of 50 per cent., the danger of spontaneous combustion is very remote.

The *natural* grease in wool has no tendency to take fire, no matter if very tightly compressed; but it becomes somewhat dangerous if it gets wet, and should therefore be kept in a dry place; then it is safe for any length of time.

CARD CLOTHING.

The first patent for a card-making machine was granted to William Pennington, as appears from British patent No. 157, dated Oct. 13, 1750. It simply held the leather tight while a tool, operated by a dividing wheel, perforated the holes for the wire teeth, at the proper distances apart.

When Samuel Slater came to America, in 1786, he got his card clothing made by Pliny Earle, of Leicester, Massachusetts, who was engaged in making hand cards. Earle obtained some calf-skins, from which he prepared a number of sheets 4 inches wide by 18 inches long, that being the width of Slater's cards. With two needles he perforated the holes for the teeth, which he inserted with his fingers. Having finished the difficult task, he delivered the first card clothing made in America to Slater, at his mill in Pawtucket, Rhode Island, and returned home with his hard-earned money.

We next find a patent granted to Clement Sharp and Amos Whittemore, — viz., British patent No. 2,322, dated June 26, 1799. This was for a complete machine, which, besides making the holes, also inserted the teeth; but could only be used for sheets, and was a very crude affair. J. C. Dyer greatly improved it, making it, in fact, a successful machine; and the firm of J. C. Dyer & Co., of Denton, near Manchester, began the business of manufacturing machine-card clothing. This firm was afterwards succeeded by James Walton & Sons, who now operate the largest establishment in the world engaged in this specialty. Mr. Walton invented the filleting machine, and the India-rubber foundation for cards, now exclusively used for cotton-card clothing, — as it would be for woollen, were it not for the difficulty that the oil used in woollen carding dissolves the rubber.

The card-setting machine may justly be styled a mechanical marvel more dexterous than human fingers. The introduction of each tooth into the foundation involves six

important movements, namely, (1) the feeding of the wire; (2) cutting it off to the required length; (3) piercing the holes for the reception of the teeth; (4) the formation of the staple; (5) carrying it forward and inserting it in the holes; and (6) then putting the "knee" bend into each tooth after the latter's insertion through the foundation. The machine performs these operations almost simultaneously, or at the rate of about 300 teeth per minute, involving some 1,800 movements in that short interval, every one of which demands unerring accuracy. It has been forcibly said, "In viewing its rapid motion, and the mechanical elegance of its movements, one is struck almost to fascination with its performances; and we consider it the most amazing piece of mechanism that human ingenuity ever invented."

Since the perfection of the card-setting machine, the improvements have consisted wholly in new foundations for the teeth, different shapes of the drawn wire, and the substitution of steel, and partly tempered steel, for the common soft iron wire.

For wool carding, cloth or leather foundations are now chiefly used, and in this country we should imagine that fully 90 per cent. is of leather. Rubber foundation is considerably used for worsted carding, as there is but little oil used, and the dampness always left in the wool for worsted carding is less injurious on rubber than on leather. But in cotton carding, where no oil is used, rubber is universal. This foundation consists of several layers of cloth, the warp of which is of linen and the weft of cotton; these are cemented together with a preparation of rubber, and on to the face a thin cover-

ing of *natural* rubber about $\frac{1}{16}$ inch thick. Such a foundation is preferable to leather, for the reasons which follow: with leather the holes for the teeth must be made somewhat larger than the wire; thus the teeth are measurably loose, and so remain. With rubber, on the contrary, the holes are pierced much smaller, and the wire is thus held in an elastic bed. With leather the strain when working is borne entirely by the wire. With the rubber and cloth foundation the rubber shares the strain, and this constitutes its valuable feature as compared with leather, and renders it far more suitable, and at the same time more durable, than the latter. Another advantage may also be mentioned, namely, that there are no splicings, therefore no liability of breakage.

When rubber foundation is specially made for worsted cards, the gum is not cemented in the form of a sheet to the cloth, as for cotton, but put on as a paste and vulcanized. The best clothing for carding wet wool has, in addition to the above, the teeth coated with tin, to prevent rust. This process is the invention of Daniel Bateman & Sons, of Low Moor, near Bradford, who claim to be the oldest house in the trade, having been established over one hundred years. This firm draw all their own wire, both iron and steel; they dress all the leather they use, and for cloth foundation they prepare the rubber from the crude state, and weave the cloth. A large part of their wire is of cast steel, and the processes for tempering are mostly of their own invention, having been now so far perfected that they can take a piece of steel wire No. 25 wire gauge over 16 miles long and impart a perfectly uniform temperature throughout its whole length. This wire in passing into the card-setting

machine has the temper "let down" by a Bunsen burner at the parts which receive the bend, so that the wire as it leaves the burner and enters the machine is alternately hard at the points and soft at the crown, and between these parts there is a gradual diminution of temper, thus making, they claim, a perfect spring of each tooth. This clothing is sent from the works already sharpened, as at first objections were made of the great length of time required to grind it with the ordinary appliances in the mills.

The sectional form of the wire used in card-making has undergone a number of changes. Beginning with round wire, which held its own for many years without an innovation, there was, first of all, perhaps, the diamond point or angular wire for feed-rolls, takers-in, etc. Then there was the Belgian, although that kind was a modification rather than change of form in the wire. In June, 1870, the flat wire card was patented by Ashworth Brothers, of Manchester, who simply flattened the round wire by compressing it between a pair of hardened steel rolls. This strengthened the wire on a well-known principle, and seemed to be the great thing until complaints were made of it injuring the foundation by its action during working, and the presence of its thin edge against the holes in the leather, etc. This was remedied by the improvement introduced by James Yates & Sons, of Cleckheaton, Yorkshire, who made their wire round at the crown, and up to the knee, but angular from there to the point. This was accomplished by a new and neat arrangement applied to the card-setting machine. This makes an open set card of a superior kind, because it is not weak sideways, nor injurious to the foundation, and strong in the direction

where the strength is required. The part above the knee, by its peculiar shape, allows for a fine point being produced and at the same time long maintaining its keenness, requiring, therefore, less grinding than for round wire, and is for that reason more durable. James Walton & Sons have a patent wire also said to be an excellent substitute for round wire. It is called "curvi-angular," and in section is in form of a triangle, round at the corners. It is usually made of steel, and compressed into shape from the round wire. The writer's father some time about 1850 invented a "fancy" set with steel pins, having heads same as the common pin, and points the same as a needle. These were set into a rubber foundation at an angle, but contained no bend whatever.

A new foundation, combining the advantages of both cloth and leather, was recently patented by the large continental card-maker, Uhlhorn, and having the two materials cemented together with India-rubber dissolved in naphtha. The benefits claimed are that the joints in the leather cannot part when stretched; that it furnishes a more elastic foundation, and greater protection of the leather against the action of grease. Felt has been used on top of cloth as a foundation, to answer the same purpose as flocks formerly were employed, that is, to fill up the wire to the knee; but it did not seem to answer very well, complaints being made that it pulled out in cleaning the cards.

A new departure in card covering, recently patented by Daniel Foxwell & Sons, Manchester, requires no teeth to be set, and for its manufacture they employ a thin sheet of steel of about No. 31 Birmingham gauge. This is cut up into widths for filleting, and then passed to a machine, where the

teeth are stabbed. This operation consists in making two slits through the sheet, meeting together at a sharp angle, and then turning up the triangular-shaped bit of metal vertically above the surface of the strip, thus forming the tooth which is attached at what may be termed the base of the triangle, the point being the apex. There are usually five teeth across the width of the fillet, and these are all punched simultaneously, working at the rate of about a yard of fillet per minute. It is intended for lickers-in, clearers, etc., where strong teeth with ample clearance between them are required. These have been run for five years without either cleaning or grinding. The fillet is wound spirally on the cylinders in the usual way, tapered at the ends with shears, and secured with tacks.

Having now conveyed to the reader as clear a description as we can command of the methods employed in the fabrication of the clothing for his cards, we will proceed to give rules and tables of use in estimating the square feet, number of points per square foot, etc., and other like useful information; but, first of all, a word or two may prove instructive concerning the differences in practice between this country and Europe in reference to card clothing.

While it is the common rule in this country to use clothing having the wire set diagonally (twill set), the common rule with English wool-carders is to use the plain set clothing, which, according to their theory, is better adapted to the proper treatment of wool fibre. The diagonal style of clothing has, of course, its uses there, being extensively used in cotton mills; but wool-carders have continued to prefer that which is plain set; and they also pre-

fer to have their own way as to the number and distribution of the card points. Time was, when the clothing-makers had it their way in many particulars, which, since the great changes effected by the introduction of shoddy, etc., the carders have insisted upon controlling; and now the maker of card clothing, when taking an order, is instructed by the carder as to the number of crowns per inch, the number of the "set," the size of wire, etc.; and these instructions have to be followed, for of all things this is the one that the English carder is bound to have his own way about. He may be told that such and such carders prefer such and such style of clothing; and he may listen to these suggestions, but, unless his own judgment approves, he cannot be induced to deviate from the teachings of his own experience. This is mentioned merely as a passing remark, and is intended only as an incitement to thought, and in the belief that practical men, who may deem it deserving of reflection, will readily see that when a carder has got a correct theory as to the treatment of the materials *he* has to card, and as to the "set" of clothing best adapted to *his* wants, it cannot be otherwise than advantageous to him and to his employer to have the clothing made in every particular precisely as he directs. Of course this freedom, freely exercised by the carder, greatly disturbs the old-time theory, or rule, which apportions to each size of wire a fixed number of points per square inch or foot. But the only rule such a carder cares about is based on his own experience, from the teachings of which he will not budge.

RULE. — *To find the number of running feet to cover any cylinder.* — The circumference is to the diameter as 22 to 7;

in other words, it answers for all practical purposes to say that the circumference of a 7-inch cylinder is 22 inches. Multiply the number of inches in length of the cylinder by the circumference, and divide by the width of fillet; the quotient gives the length in inches, which, divided by 12, gives the running feet.

To find the number of square feet.—Multiply the length of the cylinder by its circumference and divide the product by 144 (the number of inches in a square foot), and the quotient will be the answer in square feet.

For purposes of ready reference, and to save all calculation, as far as possible, a set of tables is here appended for finding the circumference of circles, and estimates for card clothing for cards of 40, 48, and 60 inches in width, these being the principal widths in use in the United States.

TABLE, showing the Circumference and Areas of Circles of Diameters from 1 to 100.

Diam.	Circumf.	Area.	Diam.	Circumf.	Area.	Diam.	Circumf.	Area.
1.	3.141	.7854	15½.	48.69	188.69	50.	157.	1693.5
1¼.	3.927	1.227	16.	50.26	201.06	51.	160.2	2042.8
1½.	4.712	1.767	16½.	51.83	213.82	52.	163.3	2123.7
1¾.	5.497	2.404	17.	53.40	226.98	53.	166.5	2206.1
2.	6.283	3.141	17½.	54.97	240.52	54.	169.6	2290.2
2¼.	7.068	3.976	18.	56.54	254.46	55.	172.7	2375.8
2½.	7.854	4.908	18½.	58.11	268.80	56.	175.9	2463.0
2¾.	8.639	5.939	19.	59.69	283.52	57.	179.	2551.7
3.	9.424	7.068	19½.	61.26	298.64	58.	182.2	2642.0
3¼.	10.21	8.295	20.	62.83	314.16	59.	185.3	2733.9
3½.	10.99	9.621	20½.	64.40	330.06	60.	188.4	2827.4
3¾.	11.78	11.044	21.	65.97	346.36	61.	191.6	2922.4
4.	12.56	12.566	21½.	67.54	363.05	62.	194.7	3019.0
4¼.	13.35	14.186	22.	69.11	380.13	63.	197.9	3117.2
4½.	14.13	15.904	22½.	70.68	397.60	64.	201.	3216.9
4¾.	14.92	17.720	23.	72.25	415.47	65.	204.2	3318.3
5.	15.70	19.635	23½.	73.82	433.73	66.	207.3	3421.2
5¼.	16.49	21.647	24.	75.39	452.39	67.	210.4	3525.6
5½.	17.27	23.758	24½.	76.96	471.43	68.	213.6	3631.6
5¾.	18.06	25.967	25.	78.54	490.87	69.	216.7	3739.2
6.	18.84	28.274	25½.	80.10	510.70	70.	219.9	3848.4
6¼.	19.63	30.679	26.	81 68	530.93	71.	223.	3959.2
6½.	20.42	33.183	26½.	83.25	551.54	72.	226.1	4071.5
6¾.	21.20	35.784	27.	84.82	572.55	73.	229.3	4185.3
7.	21.99	38.484	27½.	86.39	593.95	74.	232.4	4300.8
7¼.	22.77	41.282	28.	87.96	615.75	75.	235.6	4417.8
7½.	23.56	44.178	28½.	89.53	637.94	76.	238.7	4536.4
7¾.	24.34	47.173	29.	91.10	660.52	77.	241.9	4656.6
8.	25.13	50.265	29½.	92.67	683.49	78.	245.	4778.3
8¼.	25.91	53.456	30.	94.24	706.86	79.	248.1	4901.6
8½.	26.70	56.745	30½.	95.81	730.61	80.	251.3	5026.5
8¾.	27.48	60.131	31.	97.38	754.76	81.	254.4	5153.0
9.	28.27	63.617	31½.	98.97	779.31	82.	257.6	5281.0
9¼.	29.05	67.200	32.	100.0	804.24	83.	260.7	5410.6
9½.	29.84	70.882	33.	103.6	855.30	84.	263.8	5541.7
9¾.	30.63	74.662	34.	106.8	907.92	85.	267.	5674.5
10.	31.41	78.539	35.	109.9	962.11	86.	270.1	5808.8
10¼.	32.20	82.516	36.	113.0	1017.8	87.	273.3	5944.6
10½.	32.98	86.590	37.	116.2	1075.2	88.	276.4	6082.1
10¾.	33.77	90.762	38.	119.3	1134.1	89.	279.6	6221.1
11.	34.55	95.033	39.	122.5	1194.5	90.	282.7	6361.7
11¼.	35.34	99.402	40.	125.6	1256.6	91.	285.8	6503.8
11½.	36.12	103.86	41.	128.8	1320.2	92.	289.	6647.6
11¾.	36.91	108.43	42.	131.9	1385.4	93.	292.1	6792.9
12.	37.69	113.09	43.	135.	1452.2	94.	295.3	6939.7
12½.	39.27	122.71	44.	138.2	1520.5	95.	298.4	7088.2
13.	40.84	132.73	45.	141.3	1590.4	96.	301.5	7238.2
13½.	42.41	143.13	46.	144.5	1661.9	97.	304.7	7389.8
14.	43.98	153.93	47.	147.6	1734.9	98.	307.8	7542.9
14½.	45.55	165.13	48.	150.7	1809.5	99.	311.	7697.7
15.	47.12	176.71	49.	153.9	1885.7	100.	314.1	7853.9

EXPLANATION OF TABLES.

FILLETING. — These tables give not only the number of square feet, but also the number of running feet it will take to cover cylinders of 40, 48, and 60 inches in length, and of any diameter. For instance, take 10 cylinders, 10 inches in diameter and 48 inches in length: Turn to the table headed "Filleting for 48-inch Cards;" follow the column headed "Diameters" down to 10; then follow that row of figures to the right, and find 130½ running feet of 1-inch width; or 104½ running feet of 1¼-inch width; or 87 running feet of 1½-inch width; or 65 running feet of 2-inch width; which will cover one (1) cylinder 10 × 48. Following this row of figures still further to the right, to the column headed "10 Cylinders," find 108 square feet and 108 square inches, which is the whole number of square feet and square inches it will take to cover 10 cylinders 10 × 48. For cylinders of any other dimensions, follow the same rules.

Wherever the dot appears on the right, cut about 3 inches longer than the amount given.

Wherever the dot appears on the left, cut about 3 inches shorter than the amount given.

SHEETS. — To find the number of square feet in any number of sheets of the following lengths: viz., 40, 48, and 60 inches, and 4 and 5 inches in width. For instance, take 30 sheets 5 × 40; follow the column headed "No. of Sheets" down to 30; then follow that row of figures to the right, to the column headed "40-inch," and under 5-inch of that column is 41 square feet and .096 square inches. To find the number of square feet in any number of sheets not given in the table, add any two that will produce the required number.

FILLETING FOR 40-INCH CARDS.

Diameters.	Running feet 1 inch Fillet.	Running feet $1\frac{1}{4}$ inch Fillet.	Running feet $1\frac{1}{2}$ inch Fillet.	Running feet 2 inch Fillet.	1 Cylinder.		2 Cylind's.		3 Cylind's.		4 Cylind's		5 Cylind's.	
					Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.
1	13	. .	. .	. .	1	012	2	024	3	036	4	048	5	060
$1\frac{1}{4}$	16	. .	. .	. .	1	048	2	096	4	. .	5	048	6	096
$1\frac{1}{2}$	18	. .	. .	. .	1	072	3	. .	4	072	6	. .	7	072
$1\frac{3}{4}$	20	16	. .	. .	1	096	3	048	5	. .	6	096	8	048
2	22	18	15	. .	1	120	3	096	5	072	7	048	9	024
$2\frac{1}{2}$	28	23	19	. .	2	048	4	096	7	. .	9	048	11	096
3	34	28	23	. .	2	126	5	108	8	090	11	072	14	054
$3\frac{1}{2}$	39	31	26	. .	3	036	6	072	9	108	13	. .	16	036
4	45	36	30	. .	3	108	7	072	11	036	15	. .	18	108
$4\frac{1}{2}$	50	40	34	. .	4	036	8	072	12	108	17	. .	21	036
5	55	44	37	. .	4	090	9	036	13	126	18	072	23	018
$5\frac{1}{2}$	60	48	41	. .	5	018	10	036	15	054	20	072	25	090
6	66	53	44	. .	5	072	11	. .	16	072	22	. .	27	072
$6\frac{1}{2}$	72	58	48	. .	6	. .	12	. .	18	. .	24	. .	30	. .
7	$76\frac{1}{2}$	61	51	. .	6	054	12	108	19	018	25	072	31	126
$7\frac{1}{2}$	$82\frac{1}{2}$	66	55	. .	6	126	13	108	20	090	27	072	34	054
8	$88\frac{1}{2}$	71	59	. .	7	054	14	108	22	018	29	072	36	126
$8\frac{1}{2}$	$94\frac{1}{2}$	$75\frac{1}{2}$	63	. .	7	126	15	108	23	090	31	072	39	054
9	99	79	66	. .	8	036	16	072	24	108	33	. .	41	036
$9\frac{1}{2}$	105	84	70	. .	8	108	17	072	26	036	35	. .	43	108
10	$109\frac{1}{2}$	$87\frac{1}{2}$	73	55	9	018	18	036	27	054	36	072	45	090
$10\frac{1}{2}$	114	91	76	57	9	072	19	. .	28	072	38	. .	47	072
11	120	96	80	60	10	. .	20	. .	30	. .	40	. .	50	. .
$11\frac{1}{2}$	$124\frac{1}{2}$	$99\frac{1}{2}$	83	62	10	054	20	108	31	018	41	072	51	126
12	$130\frac{1}{2}$	$104\frac{1}{2}$	87	65	10	126	21	108	32	090	43	072	54	054
$12\frac{1}{2}$	$136\frac{1}{2}$	109	91	68	11	054	22	108	34	018	45	072	56	126
13	142	$113\frac{1}{2}$	95	71	11	120	23	096	35	072	47	048	59	024
$13\frac{1}{2}$	148	$118\frac{1}{2}$	98	74	12	048	24	096	37	. .	49	048	61	096
14	154	123	102	77	12	120	25	096	38	072	51	048	64	024
$14\frac{1}{2}$	158	126	105	79	13	024	26	048	39	072	52	096	65	120
15	162	130	108	81	13	072	27	. .	40	072	54	. .	67	072
$15\frac{1}{2}$	168	$134\frac{1}{2}$	112	84	14	. .	28	. .	42	. .	56	. .	70	. .
16	174	139	116	87	14	072	29	. .	43	072	58	. .	72	072
$16\frac{1}{2}$	178	$142\frac{1}{2}$	119	89	14	120	29	096	44	072	59	048	74	024
17	184	147	123	92	15	048	30	096	46	. .	61	048	76	096
$17\frac{1}{2}$	188	$150\frac{1}{2}$	125	94	15	096	31	048	47	. .	62	096	78	048
18	194	155	129	97	16	024	32	048	48	072	64	096	80	120
$18\frac{1}{2}$	200	160	$133\frac{1}{2}$	100	16	096	33	048	50	. .	66	096	83	048
19	206	165	$137\frac{1}{2}$	103	17	024	34	048	51	072	68	096	85	120
$19\frac{1}{2}$	210	168	140	105	17	072	35	. .	52	072	70	. .	87	072
20	216	173	144	108	18	. .	36	. .	54	. .	72	. .	90	. .
$20\frac{1}{2}$	220	176	147	110	18	048	36	096	55	. .	73	048	91	096
21	226	181	$150\frac{1}{2}$	113	18	120	37	096	56	072	75	048	94	024
$21\frac{1}{2}$	232	$185\frac{1}{2}$	$154\frac{1}{2}$	116	19	048	38	096	58	. .	77	048	96	096
22	238	$190\frac{1}{2}$	$158\frac{1}{2}$	119	19	120	39	096	59	072	79	048	99	024
$22\frac{1}{2}$	242	$193\frac{1}{2}$	161	121	20	024	40	048	60	072	80	096	100	120
23	248	$198\frac{1}{2}$	165	124	20	096	41	048	62	. .	82	096	103	048
$23\frac{1}{2}$	254	203	169	127	21	024	42	048	63	072	84	096	105	120
24	260	208	173	130	21	096	43	048	65	. .	86	096	108	048

FILLETING FOR 40-INCH CARDS.

Diameters.	Running feet 1 inch Fillet.	Running feet 1¼ inch Fillet.	Running feet 1½ inch Fillet.	Running feet 2 inch Fillet.	6 Cylind's. Sq. ft.	6 Cylind's. Sq. in.	7 Cylind's. Sq. ft.	7 Cylind's. Sq. in.	8 Cylind's. Sq. ft.	8 Cylind's. Sq. in.	9 Cylind's. Sq. ft.	9 Cylind's. Sq. in.	10 Cylind's. Sq. ft.	10 Cylind's. Sq. in.
1	13	. .	. .	. .	6	072	7	048	8	096	9	108	10	120
1¼	16	. .	. .	. .	8	. .	9	048	10	096	12	. .	13	048
1½	18	. .	. .	. .	9	. .	10	072	12	. .	13	072	15	. .
1¾	20	16	. .	. .	10	. .	11	096	13	048	15	. .	16	096
2	22	18	15	. .	11	. .	12	120	14	096	16	072	18	048
2½	28	23	19	. .	14	. .	16	048	18	096	21	. .	23	048
3	34	28	23	. .	17	036	20	018	23	. .	25	126	28	108
3½	39	31	26	. .	19	072	22	108	26	. .	29	036	32	072
4	45	36	30	. .	22	072	26	036	30	. .	33	108	37	072
4½	50	40	34	. .	25	072	29	108	34	. .	38	036	42	072
5	55	44	37	. .	27	108	32	054	37	. .	41	090	46	036
5½	60	48	41	. .	30	108	35	126	41	. .	46	018	51	036
6	66	53	44	. .	33	. .	38	072	44	. .	49	072	55	. .
6½	72	·58	48	. .	36	. .	42	. .	48	. .	54	. .	60	. .
7	76½	61·	51	. .	38	036	44	090	51	. .	57	054	63	108
7½	82½	66	55	. .	41	036	48	018	55	. .	61	126	68	108
8	88½	·71	59	. .	44	036	51	090	59	. .	66	054	73	108
8½	94½	75½	63	. .	47	036	55	018	63	. .	70	126	78	108
9	99	79·	66	. .	49	072	57	108	66	. .	74	036	82	072
9½	105	84	70	. .	52	072	61	036	70	. .	78	108	87	072
10	109½	87½	73	·55	54	108	63	126	73	. .	82	018	91	036
10½	114	91·	76	57	57	. .	66	072	76	. .	85	072	95	. .
11	120	96	80	60	60	. .	70	. .	80	. .	90	. .	100	. .
11½	124½	99½	83	62·	62	036	72	090	83	. .	93	054	103	108
12	130½	104½	87	65	65	036	76	018	87	. .	97	126	108	108
12½	136½	109·	91	68	68	036	79	090	91	. .	102	054	113	108
13	142	113½	95	71	71	. .	82	120	94	096	106	072	118	048
13½	148	118½	98	74	74	. .	86	048	98	096	111	.	123	048
14	154	123·	102	77	77	. .	89	120	102	096	115	072	128	048
14½	158	126·	105	79	79	. .	92	024	105	048	118	072	131	096
15	162	·130	108	81	81	. .	94	072	108	. .	121	072	135	. .
15½	168	134½	112	84	84	. .	98	. .	112	. .	126	. .	140	. .
16	174	139·	116	87	87	. .	101	072	116	. .	130	072	145	. .
16½	178	142½	119	89	89	. .	103	120	118	096	133	072	148	048
17	184	147·	123	92	92	. .	107	048	122	096	138	. .	153	048
17½	188	150½	125	94	94	. .	109	096	125	048	141	. .	156	096
18	194	155·	129	97	97	. .	113	024	129	048	145	072	161	096
18½	200	160	133½	100	100	. .	116	096	133	048	150	. .	166	096
19	206	·165	137½	103	103	. .	120	024	137	048	154	072	171	096
19½	210	168	140	105	105	. .	122	072	140	. .	157	072	175	. .
20	216	·173	144	108	108	. .	126	. .	144	. .	162	. .	180	. .
20½	220	176	·147	110	110	. .	128	048	146	096	165	. .	183	048
21	226	·181	150½	113	113	. .	131	120	150	096	169	072	188	048
21½	232	185½	154½	116	116	. .	135	048	154	096	174	. .	193	048
22	238	190½	158½	119	119	. .	138	120	158	096	178	072	198	048
22½	242	193½	161·	121	121	. .	141	024	161	048	181	072	201	096
23	248	198½	165·	124	124	. .	144	096	165	048	186	. .	206	096
23½	254	203·	169·	127	127	. .	148	024	169	048	190	072	211	096
24	260	208	173·	130	130	. .	151	096	173	048	195	. .	216	096

FILLETING FOR 48-INCH CARDS.

Diameters.	Running feet 1 inch Fillet.	Running feet 1¼ inch Fillet.	Running feet 1½ inch Fillet.	Running feet 2 inch Fillet.	1 Cylinder. Sq. ft.	1 Cylinder. Sq. in.	2 Cylind's. Sq. ft.	2 Cylind's. Sq. in.	3 Cylind's. Sq. ft.	3 Cylind's. Sq. in.	4 Cylind's. Sq. ft.	4 Cylind's. Sq. in.	5 Cylind's. Sq. ft.	5 Cylind's. Sq. in.
1	13	. .	. .	. .	1	012	2	024	3	036	4	048	5	060
1¼	17	. .	. .	. .	1	060	2	120	4	036	5	096	7	012
1½	20	. .	. .	. .	1	096	3	048	5	. .	6	096	8	048
1¾	24	19·	. .	. .	2	. .	4	. .	6	. .	8	. .	10	. .
2	27	21½	18	. .	2	036	4	072	6	108	9	. .	11	036
2½	34	27·	·23	. .	2	120	5	096	8	072	11	048	14	024
3	40½	32½	27	. .	3	054	6	108	10	018	13	072	16	126
3½	46½	37·	31	. .	3	126	7	108	11	090	15	072	19	054
4	52½	42	35	. .	4	054	8	108	13	018	17	072	21	126
4½	58½	·47	39	. .	4	126	9	108	14	090	19	072	24	054
5	66	·53	44	. .	5	072	11	. .	16	072	22	. .	27	072
5½	72	57½	48	. .	6	. .	12	. .	18	. .	24	. .	30	. .
6	79½	63½	53	. .	6	090	13	036	19	126	26	072	33	018
6½	84	67·	56	. .	7	. .	14	. .	21	. .	28	. .	35	. .
7	91½	73·	61	. .	7	090	15	036	22	126	30	072	38	018
7½	99	79·	66	. .	8	036	16	072	24	108	33	. .	41	036
8	105	84	70	. .	8	108	17	072	26	036	35	. .	43	108
8½	111	·89	74	. .	9	036	18	072	27	108	37	. .	46	036
9	117	93½	78	. .	9	108	19	072	29	036	39	. .	48	108
9½	124½	99½	83	. .	10	054	20	108	31	018	41	072	51	126
10	130½	104½	87	65·	10	126	21	108	32	090	43	072	54	054
10½	138	110½	92	69	11	072	23	. .	34	072	46	. .	57	072
11	144	115·	96	72	12	. .	24	. .	36	. .	48	. .	60	. .
11½	151½	121½	101	·76	12	090	25	036	37	126	50	072	63	018
12	157½	126	105	78½	13	018	26	036	39	054	52	072	65	090
12½	162	129½	108	81	13	072	27	. .	40	072	54	. .	67	072
13	166½	133·	111	83·	13	126	27	108	41	090	55	072	69	054
13½	174	139·	116	87	14	072	29	. .	43	072	58	. .	72	072
14	180	144	120	90	15	. .	30	. .	45	. .	60	. .	75	. .
14½	188	150½	125·	94	15	096	31	048	47	. .	62	096	78	048
15	194	155½	129·	97	16	024	32	048	48	072	64	096	80	120
15½	200	160	133·	100	16	096	33	048	50	. .	66	096	83	048
16	206	·165	137·	103	17	024	34	048	51	072	68	096	85	120
16½	214	171·	142½	107	17	120	35	096	53	072	71	048	89	024
17	220	176	146½	110	18	048	36	096	55	. .	73	048	91	096
17½	228	182½	152	114	19	. .	38	. .	57	. .	76	. .	95	. .
18	234	187·	156	117	19	072	39	. .	58	072	78	. .	97	072
18½	240	192	160	120	20	. .	40	. .	60	. .	80	. .	100	. .
19	246	·197	164	123	20	072	41	. .	61	072	82	. .	102	072
19½	252	·202	168	126	21	. .	42	. .	63	. .	84	. .	105	. .
20	258	206½	172	129	21	072	43	. .	64	072	86	. .	107	072
20½	266	·213	177·	133	22	024	44	048	66	072	88	096	110	120
21	272	·220	181·	136	22	096	45	048	68	. .	90	096	113	048
21½	280	224	186½	140	23	048	46	096	70	. .	93	048	116	096
22	286	·229	190½	143	23	120	47	096	71	072	95	048	119	024
22½	294	235·	196	147	24	072	49	. .	73	072	98	. .	122	072
23	300	240	200	150	25	. .	50	. .	75	. .	100	. .	125	. .
23½	306	·245	204	153	25	072	51	. .	76	072	102	. .	127	072
24	312	249½	208	156	26	. .	52	. .	78	. .	104	. .	130	. .

FILLETING FOR 48-INCH CARDS.

Diameters.	Running feet 1 inch Fillet.	Running feet 1¼ inch Fillet.	Running feet 1½ inch Fillet.	Running feet 2 inch Fillet.	6 Cylind's. Sq. ft.	6 Cylind's. Sq. in.	7 Cylind's. Sq. ft.	7 Cylind's. Sq. in.	8 Cylind's. Sq. ft.	8 Cylind's. Sq. in.	9 Cylind's. Sq. ft.	9 Cylind's. Sq. in.	10 Cylind's. Sq. ft.	10 Cylind's. Sq. in.
1	13	..	..	..	6	072	7	048	8	096	9	108	10	120
1¼	17	..	..	..	8	072	9	132	11	048	12	108	14	024
1½	20	..	..	..	10	..	11	096	13	048	15	..	16	096
1¾	24	19·	..	..	12	..	14	..	16	..	18	..	20	..
2	27	21½	18	..	13	072	15	108	18	..	20	036	22	072
2½	34	27·	·23	..	17	..	19	120	22	096	25	072	28	048
3	40½	32½	27	..	20	036	23	090	27	..	30	054	33	108
3½	46½	37·	31	..	23	036	27	018	31	..	34	126	38	108
4	52½	42	35	..	26	036	30	090	35	..	39	054	43	108
4½	58½	·47	39	..	29	036	34	018	39	..	43	126	48	108
5	66	·53	44	..	33	..	38	072	44	..	49	072	55	..
5½	72	57½	48	..	36	..	42	..	48	..	54	..	60	..
6	79½	63½	53	..	39	108	46	054	53	..	59	090	66	036
6½	84	67·	56	..	42	..	49	..	56	..	63	..	70	..
7	91½	73·	61	..	45	108	53	054	61	..	68	090	76	036
7½	99	79·	66	..	49	072	57	108	66	..	74	036	12	072
8	105	84	70	..	52	072	61	036	70	..	78	108	87	072
8½	111	·89	74	..	55	072	64	108	74	..	83	036	92	072
9	117	93½	78	..	58	072	68	036	78	..	87	108	97	072
9½	124½	99½	83	..	62	036	72	090	83	..	93	054	103	108
10	130½	104½	87	65	65	036	76	018	87	..	97	126	108	108
10½	138	110½	92	69	69	..	80	072	92	..	103	072	115	..
11	144	115·	96	72	72	..	84	..	96	..	108	..	120	..
11½	151½	121½	101	·76	75	108	88	054	101	..	113	090	126	036
12	157½	126	105	78½	78	108	91	126	105	..	118	018	131	036
12½	162	129½	108	81	81	..	94	072	108	..	121	072	135	..
13	166½	133·	111	83·	83	036	97	018	111	..	124	126	138	108
13½	174	139·	116	87	87	..	101	072	116	..	130	072	145	..
14	180	144	120	90	90	..	105	..	120	..	135	..	100	..
14½	188	150½	125·	94	94	..	109	096	125	048	141	..	156	096
15	194	155½	129·	97	97	..	113	024	129	048	145	072	161	096
15½	200	160	133·	100	100	..	116	096	133	048	150	..	166	096
16	206	·165	137·	103	103	..	120	024	137	048	154	072	171	096
16½	214	171·	142½	107	107	..	124	120	142	096	160	072	178	048
17	220	176	146½	110	110	..	128	048	146	096	165	..	183	048
17½	228	182½	152	114	114	..	133	..	152	..	171	..	190	..
18	234	187	156	117	117	..	136	072	156	..	175	072	195	..
18½	240	192	160	120	120	..	140	..	160	..	180	..	200	..
19	246	·197	164	123	123	..	143	072	164	..	184	072	205	..
19½	252	·202	168	126	126	..	147	..	168	..	189	..	210	..
20	258	206½	172	129	129	..	150	072	172	..	193	072	215	..
20½	266	·213	177·	133	133	..	155	024	177	048	199	072	221	096
21	272	·220	181·	136	136	..	158	096	181	048	204	..	226	096
21½	280	224	186½	140	140	..	163	048	186	096	210	..	233	048
22	286	·229	190½	143	143	..	166	120	190	096	214	072	238	048
22½	294	235·	196	147	147	..	171	072	196	..	220	072	245	..
23	300	240	200	150	150	..	175	..	200	..	225	..	250	..
23½	306	·245	204	153	153	..	178	072	204	..	229	072	255	..
24	312	249½	208	156	156	..	182	..	208	..	234	..	260	..

FILLETING FOR 60-INCH CARDS.

Diameters.	Running feet 1 inch Fillet.	Running feet 1¼ inch Fillet.	Running feet 1½ inch Fillet.	Running feet 2 inch Fillet.	1 Cylinder. Sq. ft.	Sq. in.	2 Cylind's. Sq. ft.	Sq. in.	3 Cylind's. Sq. ft.	Sq. in.	4 Cylind's. Sq. ft.	Sq. in.	5 Cylind's. Sq. ft.	Sq. in.
1	15	. .	. .	. .	1	036	2	072	3	108	5	. .	6	036
1¼	20	. .	. .	. .	1	096	3	048	5	. .	6	096	8	048
1½	25	. .	. .	. .	2	012	4	024	6	036	8	048	10	060
1¾	30	24	. .	. .	2	072	5	. .	7	072	10	. .	12	072
2	35	28	23·	. .	2	132	5	120	8	108	11	096	14	084
2½	43	34½	·29	. .	3	084	7	024	10	108	14	048	17	132
3	49½	39½	33	. .	4	018	8	036	12	054	16	072	20	090
3½	57	·46	38	. .	4	108	9	072	14	036	19	. .	23	108
4	64½	·52	43	. .	5	054	10	108	16	018	21	072	26	126
4½	73½	·59	49	. .	6	018	12	036	18	054	24	072	30	090
5	81	·65	54	. .	6	108	13	072	20	036	27	. .	33	108
5½	90	72	60	. .	7	072	15	. .	22	072	30	. .	37	072
6	97½	78	65	. .	8	018	16	036	24	054	32	072	40	090
6½	106½	85·	71	. .	8	126	17	108	26	090	35	072	44	054
7	114	91·	76	. .	9	072	19	. .	28	072	38	. .	47	072
7½	121½	97·	81	. .	10	018	20	036	30	054	40	072	50	090
8	130½	104½	87	. .	10	126	21	108	32	090	43	072	54	054
8½	138	110½	92	. .	11	072	23	. .	34	072	46	. .	57	072
9	145½	116½	97	. .	12	018	24	036	36	054	48	072	60	090
9½	154½	123½	103	. .	12	126	25	108	38	090	51	072	64	054
10	162	·130	108	81	13	072	27	. .	40	072	54	. .	67	072
10½	171	·137	114	85½	14	036	28	072	42	108	57	. .	71	036
11	178½	·143	119	89·	14	126	29	108	44	090	59	072	74	054
11½	187½	150	125	·94	15	090	31	036	46	126	62	072	78	018
12	195	156	130	97½	16	036	32	072	48	108	65	. .	81	036
12½	204	163·	136	102	17	. .	34	. .	51	. .	68	. .	85	. .
13	211½	169·	141	·106	17	090	35	036	52	126	70	072	88	018
13½	220½	176½	147	110·	18	054	36	108	55	018	73	072	91	126
14	228	182½	152	114	19	. .	38	. .	57	. .	76	. .	95	. .
14½	236	·189	157·	118	19	096	39	048	59	. .	78	096	98	048
15	244	195·	·163	122	20	048	40	096	61	. .	81	048	101	096
15½	252	·202	168	126	21	. .	42	. .	63	. .	84	. .	105	. .
16	260	208	173·	130	21	096	43	048	65	. .	86	096	108	048
16½	268	214½	178½	134	22	048	44	096	67	. .	89	048	111	096
17	276	221	184	138	23	. .	46	. .	69	. .	92	. .	115	. .
17½	284	227·	189·	142	23	096	47	048	71	. .	94	096	118	048
18	292	·234	·194	146	24	048	48	096	73	. .	97	048	121	096
18½	300	240	200	150	25	. .	50	. .	75	. .	100	. .	125	. .
19	308	246½	205·	154	25	096	51	048	77	. .	102	096	128	048
19½	316	·253	·211	158	26	048	52	096	79	. .	105	048	131	096
20	324	259·	216	162	27	. .	54	. .	81	. .	108	. .	135	. .
20½	332	·266	221·	166	27	096	55	048	83	. .	110	096	138	048
21	340	272	·227	170	28	048	56	096	85	. .	113	048	141	096
21½	348	278½	232	174	29	. .	58	. .	87	. .	116	. .	145	. .
22	356	·285	237·	178	29	096	59	048	89	. .	118	096	148	048
22½	364	291·	·243	182	30	048	60	096	91	. .	121	048	151	096
23	372	.298	248	186	31	. .	62	. .	93	. .	124	. .	155	. .
23½	380	304	253·	190	31	096	63	048	95	. .	126	096	158	048
24	388	310½	·259	194	32	048	64	096	97	. .	129	048	161	096

FILLETING FOR 60-INCH CARDS.

Diameters.	Running feet 1 inch Fillet.	Running feet 1¼ inch Fillet.	Running feet 1½ inch Fillet.	Running feet 2 inch Fillet.	6 Cylind's.		7 Cylind's.		8 Cylind's.		9 Cylind's.		10 Cylind's.	
					Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.
1	15	. .	. .	. .	7	072	8	108	10	. .	11	036	12	072
1¼	20	. .	. .	. .	10	. .	11	096	13	048	15	. .	16	096
1½	25	. .	. .	. .	12	072	14	084	16	096	18	108	20	120.
1¾	30	24	. .	. .	15	. .	17	072	20	. .	22	072	25	. .
2	35	28	23·	. .	17	072	20	060	23	048	26	036	29	024
2½	43	34½	·29	. .	21	072	25	012	28	096	32	036	35	120
3	49½	39½	33	. .	24	108	28	126	33	. .	37	018	41	036
3½	57	·46	38	. .	28	072	33	036	38	. .	42	108	47	072
4	64½	·52	43	. .	32	036	37	090	43	. .	48	054	53	108
4½	73½	·59	49	. .	36	108	42	126	49	. .	55	018	61	036
5	81	·65	54	. .	40	072	47	056	54	. .	60	108	67	072
5½	90	72	60	. .	45	. .	52	072	60	. .	67	072	75	. .
6	97½	78	65	. .	48	108	56	126	65	. .	73	018	81	036
6½	106½	85·	71	. .	53	036	62	018	71	. .	79	126	88	108
7	114	91·	76	. .	57	. .	66	072	76	. .	85	072	95	. .
7½	121½	97·	81	. .	60	108	70	126	81	. .	91	018	101	036
8	130½	104½	87	. .	65	036	76	018	87	. .	97	126	108	108
8½	138	110½	92	. .	69	. .	80	072	92	. .	103	072	115	. .
9	145½	116½	97	. .	72	108	84	126	97	. .	109	018	121	036
9½	154½	123½	103	. .	77	036	90	018	103	. .	115	126	128	108
10	162	·130	108	81	81	. .	94	072	108	. .	121	072	135	. .
10½	171	·137	114	85½	85	072	99	108	114	. .	128	036	142	072
11	178½	·143	119	89·	89	036	104	018	119	. .	133	126	148	108
11½	187½	150	125	·94	93	108	109	054	125	. .	140	090	156	036
12	195	156	130	97½	97	072	113	108	130	. .	146	036	162	072
12½	204	163·	136	102	102	. .	119	. .	136	. .	153	. .	170	. .
13	211½	169·	141	106	105	108	123	054	141	. .	158	090	176	036
13½	220½	176½	147	110·	110	036	128	090	147	. .	165	054	183	108
14	228	182½	152	114	114	. .	133	. .	152	. .	171	. .	190	. .
14½	236	·189	157·	118	118	. .	137	096	157	048	177	. .	196	096
15	244	195·	·163	122	122	. .	142	048	162	096	183	. .	203	048
15½	252	·202	168	126	126	. .	147	. .	168	. .	189	. .	210	. .
16	260	208	173·	130	130	. .	151	096	173	048	195	. .	216	096
16½	268	214½	178½	134	134	. .	156	048	178	096	201	. .	223	048
17	276	221	184	138	138	. .	161	. .	184	. .	207	. .	230	. .
17½	284	227·	189·	142	142	. .	165	096	189	048	213	. .	236	096
18	292	·234	·194	146	146	. .	170	048	194	096	219	. .	243	048
18½	300	240	200	150	150	. .	175	. .	200	. .	225	. .	250	. .
19	308	246½	205·	154	154	. .	179	096	205	048	231	. .	256	096
19½	316	·253	·211	158	158	. .	184	048	210	096	237	. .	263	048
20	324	259·	216	162	162	. .	189	. .	216	. .	243	. .	270	. .
20½	332	·266	221·	166	166	. .	193	096	221	048	249	. .	276	096
21	340	272	·227	170	170	. .	198	048	226	096	255	. .	283	048
21½	348	278½	232	174	174	. .	203	. .	232	. .	261	. .	290	. .
22	356	·285	237·	178	178	. .	207	096	237	048	267	. .	296	096
22½	364	291·	·243	182	182	. .	212	058	242	096	273	. .	303	048
23	372	·298	248	186	186	. .	217	. .	248	. .	279	. .	310	. .
23½	380	304	253·	190	190	. .	221	096	253	048	285	. .	316	096
24	388	310½	·259	194	194	. .	226	048	258	096	291	. .	323	048

SHEETS.

Length.	40-inch.				48-inch.				60-inch.			
Width.	4-inch.		5-inch.		4-inch.		5-inch.		4-inch.		5-inch.	
No. of Sheets.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.	Sq. ft.	Sq. in.
1	1	016	1	056	1	048	1	096	1	096	2	012
2	2	032	2	112	2	096	3	048	3	048	4	024
3	3	048	4	024	4	. .	5	. .	5	. .	6	036
4	4	064	5	080	5	048	6	096	6	096	8	048
5	5	080	6	136	6	096	8	048	8	048	10	060
6	6	096	8	048	8	. .	10	. .	10	. .	12	072
7	7	112	9	104	9	048	11	096	11	096	14	084
8	8	128	11	016	10	096	13	048	13	048	16	096
9	10	. .	12	072	12	. .	15	. .	15	. .	18	108
10	11	016	13	128	13	048	16	096	16	096	20	120
11	12	032	15	040	14	096	18	048	18	048	22	132
12	13	048	16	096	16	. .	20	. .	20	. .	25	. .
13	14	064	18	008	17	048	21	096	21	096	27	112
14	15	080	19	064	18	096	23	048	23	048	29	024
15	16	096	20	120	20	. .	25	. .	25	. .	31	036
16	17	112	22	032	21	048	26	096	26	096	33	048
17	18	128	23	088	22	096	28	048	28	048	35	060
18	20	. .	25	. .	24	. .	30	. .	30	. .	37	072
19	21	016	26	056	25	048	31	096	31	096	39	084
20	22	032	27	112	26	096	33	048	33	048	41	096
21	23	048	29	024	28	. .	35	. .	35	. .	43	108
22	24	064	30	080	29	048	36	096	36	096	45	120
23	25	080	31	136	30	096	38	048	38	048	47	132
24	26	096	33	048	32	. .	40	. .	40	. .	50	. .
25	27	112	34	104	33	048	41	096	41	096	52	012
26	28	128	36	016	34	096	43	048	43	048	54	024
27	30	. .	37	072	36	. .	45	. .	45	. .	56	036
28	31	016	38	128	37	048	46	096	46	096	58	048
29	32	032	40	040	38	096	48	048	48	048	60	060
30	33	048	41	096	40	. .	50	. .	50	. .	62	072
36	40	. .	50	. .	48	. .	60	. .	60	. .	75	. .
38	42	032	52	112	50	096	63	048	63	048	79	024
40	44	064	55	080	53	048	66	096	66	096	83	048
42	46	096	58	048	56	. .	70	. .	70	. .	87	072
44	48	128	61	016	58	096	73	048	73	048	91	096
46	51	016	63	128	61	048	76	096	76	096	95	120
48	53	048	66	096	64	. .	80	. .	80	. .	100	. .
50	55	080	69	064	66	096	83	048	83	048	104	024
60	66	096	83	048	80	. .	100	. .	100	. .	125	. .
70	77	112	97	032	93	048	116	096	116	096	145	120
80	88	128	111	016	106	096	133	048	133	048	166	096
90	100	. .	125	090	120	. .	150	. .	150	. .	187	072
100	111	016	138	128	133	048	166	096	166	096	208	048

Amount of Card Clothing usually employed on an ordinary Set of 48-inch Cards.

No.	Cylinders.	Dimensions.	Length.	Width.	Sq. ft.
		FIRST BREAKER.			
24	Sheets	5 × 48	. . . .	. . . . . .	40
6	Workers	7 × 48	each 61 feet.	1½ inch.	45¾
6	Strippers	3 × 48	" 27 "	1½ "	20½
1	Doffer	18 × 48	" 117 "	2 "	19½
1	Fancy	9 × 48	" 78 "	1½ "	9¾
1	Tumbler	7 × 48	" 61 "	1½ "	7⅝
2	Feed-Rolls . . .	1¾ × 48	" 24 "	1 Angular.	4
		SECOND BREAKER.			
24	Sheets	5 × 48	. . . .	. . . . . .	40
6	Workers	7 × 48	each 61 feet.	1½ inch.	45¾
6	Strippers	3 × 48	" 27 "	1½ "	20¼
1	Doffer	18 × 48	" 117 "	2 "	19½
1	Fancy	9 × 48	" 78 "	1½ "	9¾
1	Tumbler	7 × 48	" 61 "	1½ "	7⅝
1	Leader-in	7 × 48	" 61 "	1½ Angular.	7⅝
1	Feed-Stripper .	1⅝ × 48	" 24 "	1 "	2
2	Feed-Rolls . . .	1¾ × 48	" 24 "	1 "	4
		FINISHER.			
24	Sheets	5 × 48	. . . .	. . . . . .	40
5	Workers	7 × 48	each 61 feet.	1½ inch.	38⅛
5	Strippers	3 × 48	" 27 "	1½ "	16⅞
1	Fancy	9 × 48	" 78 "	1½ "	9¾
1	Tumbler	7 × 48	" 61 "	1½ "	7⅝
1	Leader-in	7 × 48	" 61 "	1½ Angular.	7⅝
1	Feed-Stripper .	1⅝ × 48	" 24 "	1½ "	2
2	Feed-Rolls . . .	1¾ × 48	" 25 "	1 "	4
48	Rings	9 × 48			
		Aggregate	square feet Ro	und Wire .	398⅛
		"	" " An	gular " .	31¼
				Total . .	429⅜

Amount of Card Clothing required for a 60-inch Set of Cards with Breast.

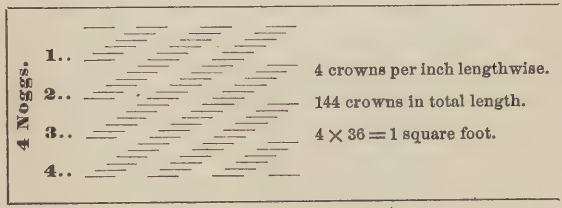
No.	Cylinders.	Dimensions.	Length.	Width.	Sq. Ft.
			FIRST BREAKER.		
1	Breast Cylinder . .	36×60	each 292 feet.	2 in.	$48\frac{2}{3}$
2	Workers	7×60	" 76 "	$1\frac{1}{2}$ "	19
2	Strippers	$3\frac{1}{2} \times 60$	" 38 "	$1\frac{1}{2}$ "	$9\frac{1}{2}$
1	Fancy	12×60	" 130 "	$1\frac{1}{2}$ "	$16\frac{1}{4}$
1	Angle-Stripper . .	6×60	" 65 "	$1\frac{1}{2}$ "	$8\frac{1}{8}$
2	Feed-Rolls	2×60	" 23 "	$1\frac{1}{2}$ " Angular	$5\frac{5}{6}$
1	Tumbler	13×60	" 141 "	$1\frac{1}{2}$ " "	$17\frac{5}{8}$
1	Intermediate Doffer	18×60	" 146 "	2 "	$24\frac{1}{3}$
1	Main Cylinder . .	48×60	24 Sheets	5×60	50
4	Workers	7×60	" 76 feet.	$1\frac{1}{2}$ in.	38
4	Strippers	$3\frac{1}{2} \times 60$	" 38 "	$1\frac{1}{2}$ "	19
1	Fancy	12×60	" 130 "	$1\frac{1}{2}$ "	$16\frac{1}{4}$
1	Doffer	30×60	" 244 "	2 "	$40\frac{2}{3}$
1	Doffer Tickler . .	3×60	" 33 "	$1\frac{1}{2}$ "	$4\frac{1}{8}$
			SECOND BREAKER.		
1	Main Cylinder . .	48×60	24 Sheets	5×60	50
4	Workers	7×60	each 76 feet.	$1\frac{1}{2}$ in.	38
4	Strippers	$3\frac{1}{2} \times 60$	" 38 "	$1\frac{1}{2}$ "	19
1	Fancy	12×60	" 130 "	$1\frac{1}{2}$ "	$16\frac{1}{4}$
1	Doffer	30×60	" 244 "	2 "	$40\frac{2}{3}$
1	Doffer Tickler . .	3×60	" 33 "	$1\frac{1}{2}$ "	$4\frac{1}{8}$
1	Tumbler	16×60	" 173 "	$1\frac{1}{2}$ " Angular	$21\frac{2}{3}$
1	Angle-Stripper . .	7×60	" 76 "	$1\frac{1}{2}$ " "	$9\frac{1}{2}$
2	Feed-Rolls	2×60	" 35 "	1 " "	$5\frac{5}{6}$
1	Feed-Roll Stripper	$1\frac{1}{2} \times 60$	" 25 "	1 " "	$2\frac{1}{12}$
			FINISHER.		
1	Main Cylinder . .	48×60	24 Sheets	5×60	50
4	Workers	7×60	each 76 feet.	$1\frac{1}{2}$ in.	38
4	Strippers	$3\frac{1}{2} \times 60$	" 38 "	$1\frac{1}{2}$ "	19
1	Fancy	12×60	" 130 "	$1\frac{1}{2}$ "	$16\frac{1}{4}$
2	Feed-Rolls	2×60	" 35 "	1 " Angular	$5\frac{5}{6}$
1	Feed-Roll Stripper	$1\frac{1}{2} \times 60$	" 25 "	1 " "	$2\frac{1}{12}$
1	Tumbler	16×60	" 173 "	$1\frac{1}{2}$ " "	$21\frac{2}{3}$
1	Angle-Stripper . .	7×60	" 76 "	$1\frac{1}{2}$ " "	$9\frac{1}{2}$
2	Doffers	10×60	" 81 "	2 "	27
	Calculated to have	60 Rings.			
		Aggregate	square feet Ro	und Wire . .	$612\frac{5}{24}$
		"	" " An	gular Wire .	$101\frac{5}{8}$
				Total . . .	$713\frac{5}{6}$

On the Size of Wire in Card Clothing.—We have hitherto said little or nothing in reference to the best size of wire for the teeth in cards, for the reason that no rule or set of rules can be arranged. All we can say must necessarily embrace only general remarks for the carder's guidance. We may say that it is always best to have the wire fine enough; coarse card clothing is becoming a thing of the past, as it is found that finer wire, with well-prepared wool, etc., gives more points, and therefore admits of better carding. Finer wire is also more elastic, and allows of a more open set of same number of points per square inch than coarser wire; and if nothing is allowed to come in contact with it but the fibres of the materials worked, it will prove as durable, while it cannot injure the staple of the wool, and is more easily kept in order. Where only one uniform kind of material is carded, the clothing can be perfectly adapted to it; and where it is necessary to card several qualities, varying considerably, it is best to have the clothing fine enough for the best quality expected to be carded, and the coarser kinds will not suffer by it; neither will the clothing, with proper care. I fail to see that a number more or less in the size of wire can make any serious difference, and would always have it on the fine side, then take great care to maintain it in good order, which is about all that can be recommended, and all that is essential.

The following diagram and simple rules will enable any one to estimate the size of wire and the "set" or number of points per square inch.

All sheet cards (except plain set, which are seldom

used in this country) are made with 4 crowns per inch in length of sheet, and in the width any number of "noggs" according to the number of "points" required. These terms and their meaning will be better understood by reference to the annexed diagram, supposed to represent a sheet of card-clothing 36 inches long, — a length not often met with, but which makes the explanation more simple.



A sheet 4×36 equals 1 square foot; there are 144 crowns with 2 points to the crown. The above sheet has 4 noggs, with 6 teeth to the nogg; therefore, to get the number of points per square foot, multiply $144 \times 2 = 288 \times 24 = 6{,}912$.

Rule. — To ascertain the number of points per square foot in twill set sheet cards, of 4 crowns per inch, multiply 6,912 by the number of noggs per inch.

To find the number of points per square foot in fillet. — Multiply the number of noggs per inch by 3,456 for cards of 4 crowns per inch, which is the kind almost exclusively made in America.

Card-clothing manufacturers have adopted the following number of points per square foot for the different sizes

of wire enumerated; and, unless otherwise directed, they fill all orders as subjoined: —

SHEETS.

No. 28 wire	. . . .	5 noggs per inch			= 34,560
" 30 "	. . . .	6 "	"	"	= 41,472
" 32 "	. . . .	7 "	"	"	= 48,384
" 33 "	. . . .	8 "	"	"	= 55,296
" 34 "	. . . .	9 "	"	"	= 62,208
" 35 "	. . . .	10 "	"	"	= 69,120
" 36 "	. . . .	11 "	"	"	= 76,032

FILLETING.

No. 28 wire	. . . .	10 noggs per inch			= 34,560
" 30 "	. . . .	12 "	"	"	= 41,472
" 32 "	. . . .	14 "	"	"	= 48,384
" 33 "	. . . .	16 "	"	"	= 55,296
" 34 "	. . . .	18 "	"	"	= 62,208
" 35 "	. . . .	20 "	"	"	= 69,120
" 36 "	. . . .	22 "	"	"	= 76,032

Every nogg added per inch increases the number of points per square foot 6,912 for sheets, and 3,456 for filleting, excepting the fancy, which is made of 4 crown, but set as follows for 1½ inch filleting: —

No. 28 wire	. . . .	10 noggs per inch			= 23,040
" 30 "	. . . .	11 "	"	"	= 25,344
" 32 "	. . . .	12 "	"	"	= 27,648
" 33 "	. . . .	13 "	"	"	= 29,952
" 34 "	. . . .	15 "	"	"	= 33,560
" 35 "	. . . .	16 "	"	"	= 36,864
" 36 "	. . . .	17 "	"	"	= 39,168

Every nogg added per inch increases the number of points per square foot 2,304.

Repairing Burr–Cylinders or Garnet Rolls.

When these become dull it is no easy matter to restore the points; but we will give directions, which, with care, will enable the carder to greatly improve them. When the teeth have their points worn off, then the metal immediately behind the points stands above them, and it is necessary to reduce the same until the edge or point is reached so that the wool can be laid hold of, the extreme edge of each tooth being brought even with the surface of the metal. Unless this fact is borne in mind, it would be a very difficult matter to do a satisfactory job. Some of the teeth will not be worn as bad as the others, therefore they will first become sharp; and this fact indicates that the teeth must point *towards* the grinding or other means used for removing the metal, else a portion of the teeth arriving at an edge before the rest would become hooked. If the cylinder is very dull it should be put in an engine lathe and the surface turned until true and level with the points, having the latter pointing towards the tool, which must be sharp and at a proper cutting elevation. A good machinist ought to do this under the carder's supervision and direction. If it is not very badly worn the surface can be ground off with a finely covered emery cylinder or traverse-grinder; or a file may be fixed in the tool-post of the turning-rest so as to bear on the cylinder, which is made to revolve in either case towards the file or grinder at about 250 or 300 turns per minute.

Whichever of the above plans is employed, the cylinder will be left in a rough state; and the next thing is to

smoothen it by removing the wire edge or burr on the edges and surface of the teeth. To do this, the cylinder or roll must be made to revolve in the opposite direction; that is, with the points running *from* the implement. A pine stick dipped in flour of emery, and oil, and pressed endwise against the teeth, so that the latter will wear notches in the end of the stick, is a good way for getting them smooth. Taking a few rows at a time, and not being in too much of a hurry, the teeth may be made both sharp and smooth, and the cylinder given a new lease of usefulness.

Care must be used not to overheat a metal cylinder of this sort when grinding or turning its surface, or the variable expansion will injuriously affect its truth. If the grinder is employed, the burr-cylinder must revolve quite slowly, say ten turns per minute, and be set on very gradually and lightly. In order to test the progress of the work, the hand should be pressed on and moved slightly against the teeth, to feel if the point has been attained, and to prevent the possibility of grinding too much; but it cannot be expected that a point as keen to the touch as a wire card can be had, and therefore the carder must govern himself accordingly. It is a job requiring time, and should not be undertaken unless there is from one to two days during which the cylinder will not be required.

On the Proper Speed of a Burr-Guard. — Where low stock is used along with wool, or where the wool is short, I have seen a painful amount of good stuff deposited into the burr-box, not because the burr-cylinder was dull, but on account of the high velocity of the guard. It will be seen, on reflection, that all short "locks," "nubs," etc., must neces-

sarily lie on the surface of the cylinder, the teeth not being able to lay hold of them, and thus they are propelled into the box the moment they reach the guard, which, nine times out of ten, has a surface speed about ten times as fast as the cylinder beneath. That there is no need whatever for this can easily be demonstrated by experiments which each can try for himself.

The object of the burr-guard is to obstruct refuse substances, such as burrs, and by so doing enable the cylinder to detach the fibres by which they are surrounded until freed of such fibres, and then eject the substance into a receptacle, that they may not, by going into the card, injure the delicate wire of the clothing. Such is the office of the guard, and, if it is properly adjusted, very little, if any, fibre will be ejected. We have seen an experiment tried by which the waste was reduced from 2½ lbs. in one day to the same amount in one week, by simply reducing the velocity of the guard so that its surface speed should exceed that of the burr-cylinder just sufficiently to prevent refuse from passing. How slow a speed is advisable depends on many other circumstances; hence we say to the carder, try a few experiments, and save yourself the trouble of continually mixing this stuff in the wool, only to be knocked out again, and also save the constant liability of the stuff going over into the card, and the great injury resulting therefrom.

Hints on covering Grinding Surfaces with Emery.

A great many failures result in covering rolls, cylinders, etc., with emery, from a non-observance of a few simple

items. The *glue* should be well cooked in a steam-pot, and be of rather thick consistency as compared to its ordinary condition, and everything about it must be clean and fresh. Use powdered glue of the best and strongest quality; cheap glue is worthless, and the dearest, by far, in the end. The *brush* should be a flat one, say $2\frac{1}{2}$ or 3 inches wide, always kept in a clean place, and thoroughly washed after use. A wire should run across the glue-pot to draw the brush over, and thereby prevent too much being lifted. The *emery* should first be sifted through a fine sieve, such as moulders use; then it must be washed in clear warm water to which a little soda has been added, and repeatedly rinsed in clean warm water afterwards, to remove the soda. Place it on a clean cloth in the sun, out of the dust, or in some warm place, and keep it exposed long enough to become thoroughly dry. The *surface* to be covered must also be clean, and if it is an iron cylinder it should have a good, true surface, free from rust. To apply the emery, the cylinder should be warmed as well as the emery, and the operation conducted in a room having a temperature of 80° or 90° F., or near a stove, etc. A box may be provided as long as the cylinder, and in the form of a V, to the inner side of which a slide can be arranged to stop the opening in the bottom, which forms a slit, say $\frac{3}{16}$ inch wide, the whole length of the box. Into this the emery is put, and it is fixed, with two end pieces for supports, immediately over the centre of the roller to be covered, the supports resting on some part of the grinder, or fixed to the framework. A crank is put on the end of the cylinder, and a boy slowly turns it. With the roller warm, as we have instructed, and the

glue hot, cover the whole surface quickly, drawing the brush from end to end. Then remove the glue-pot, and draw the slide, when a sheet of emery will be evenly distributed over the entire surface, the boy turning somewhat faster during the operation, but yet quite slow. A receptacle beneath must be arranged to receive the surplus emery, and the bottom of the box containing it must not be more than a few inches above the roller. Another roll of wood, such as a worker, can now be placed near and parallel to the cylinder, and gradually allowed to press against its surface while slowly revolving, in order to press all high grains equal; and it must not be set on too hard. The roll may be fixed above the centre of the cylinder, and its weight will then be sufficient. A few turns will suffice, when it can be removed; but the cylinder must be continually kept in motion until the glue has set. Next morning a size can be made by thinning down the glue, and using a round brush to stab in the size amongst the grains of emery, not lifting too much in the brush at one time, and not drawing the brush over the surface, but holding it vertically over the roller, dabbing in the bristles amongst the grains. When this is thoroughly dry the roller can be revolved at 300 turns per minute, and a strip of sheet-iron, or saw-blade, fixed in the tool-post of the turning-rest, may be run across slowly, and set so as to knock off the very high single grains, but no others.

The above hints can be applied to the covering of the emery-wheel as found in traverse-grinders, and to flat surfaces, as "fiddles," "strickles," etc., by slight modifications, which will readily suggest themselves.

To clean an emery-roll which has been in use, and become more or less filled with grease and wire dust, nothing is better than alcohol applied with a soft brush. Emery can be used a second time by immersing the roller in hot water, and by repeated washings of the emery after removal from the cylinder.

Oil should always be used in grinding with emery, for if the dry emery is used the teeth will be left quite rough and unfit to be put to work unless smoothened with a fiddle, or emery-board and oil.

Never attempt to put more than one coat of emery on a roll, nor try to fill up vacant places by patching, nor putting on a coat of finer grade to fill up the interstices between the coarse grains or imperfect first covering. All such botching must end in failure to obtain an even, true surface. If the first attempt fails begin entirely afresh; it is the only way.

Before iron cylinders or traverse wheels are covered they should be neatly wound with twine, or wrapped with coarse cotton cloth carefully glued on; but the cloth should only make one turn around the cylinder, the ends or edges being brought to a smooth joint. If cloth is used it is best to first have the cylinder painted, which, when thoroughly dry, will hold the glue better than a smooth iron surface. The twine is best for traverse pulleys, and it does not need to be glued, but merely wound on as tight as possible. It affords a good surface for the glue, and the hollows between the rows of twine serve to excellently retain the emery.

In Europe it has now become a distinct business, this covering of grinding surfaces, by experts who have patented improvements facilitating the work; and it is a specialty

which ought to be undertaken in this country, for it is not possible to do the job as well in a mill, with so many other things pressing on one's attention, and amidst the grease and flying fibres, as in a shop devoted to such work, fitted up with the special appliances necessary.

To estimate the Contents of Cisterns, etc. — Carders often have occasion to know the capacity of cisterns, tubs, etc., used in the scouring of wool, and we therefore give a table below, showing the CONTENTS OF CIRCULAR CISTERNS FROM 1 FOOT TO 25 FEET IN DIAMETER FOR EACH INCH IN DEPTH.

Diameter.	Gallons.	Diameter.	Gallons.
1 foot	.489	7½ feet	27.107
1½ feet	1.101	8 "	31.334
2 "	1.958	8½ "	35.373
2½ "	3.054	9 "	39.657
3 "	4.406	9½ "	44.186
3½ "	5.998	10 "	48.96
4 "	7.883	11 "	59.24
4½ "	9.911	12 "	70.5
5 "	12.24	13 "	82.745
5½ "	14.854	14 "	95.961
6 "	17.625	15 "	110.161
6½ "	20.685	20 "	195.842
7 "	23.99	25 "	305.993

In case the tub or cistern is larger at one end than the other get the mean diameter.

We also append a table showing the CONTENTS OF CIRCULAR CISTERNS, IN BARRELS, FOR EACH FOOT IN DEPTH: —

Diameter.	Barrels.	Diameter.	Barrels.
5 feet	4.66	8 feet	11.93
6 "	6.74	9 "	15.10
7 "	9.13	10 "	18.65

To find the number of gallons in a square or oblong square cistern. — RULE. — Multiply the length in inches by the width in inches, and that by the depth in inches, and divide the product by 231. The quotient will be the number of gallons.

SHAFTS, BELTING, ETC.

Whether a belt will transmit more useful effect with the hair or flesh side to the pulley is an interesting question for carders; and perhaps nothing can more conclusively show the effect one way or the other than to briefly glance at the experiments made by S. B. Hoyt & Co., of New York, and their results. These experiments also demonstrated which of several styles of pulley surfaces furnished the greatest friction.

Four kinds of pulleys were fixed upon a shaft, — rough iron ones; polished iron; iron covered with leather; and polished mahogany ones. Half of these had the belts applied with the hair side, and the other half with the flesh side, to the faces of the pulleys. The belts were fixed at one end, passed over the pulleys, and then weighted to the extent of 1 pound for every square inch of contact. It was desired to know the weight in pounds applied to the end of a lever on the pulley-shaft required, first, to make the belt

just slip; second, to make it slip moderately; third, to make it continually slip.

	Hair side to pulley.			Flesh side to pulley.			Relative value of pulley.
	1	2	3	1	2	3	
Pulley covered with leather . .	6	$2\frac{1}{2}$	10	$3\frac{1}{2}$	$2\frac{1}{4}$	7	$31\frac{1}{4}$
Polished iron pulley	$1\frac{1}{2}$	1	9	$1\frac{1}{4}$	$\frac{3}{4}$	$6\frac{1}{2}$	20
Rough iron pulley	$1\frac{1}{2}$	$\frac{3}{4}$	3	$1\frac{1}{2}$	$\frac{3}{4}$	$2\frac{1}{4}$	$9\frac{3}{4}$
Polished mahogany pulley . . .	$3\frac{3}{4}$	$2\frac{1}{4}$	4	3	$1\frac{1}{2}$	$3\frac{1}{4}$	$17\frac{3}{4}$
	$45\frac{1}{4}$			$33\frac{1}{4}$			

From the above we learn that a pulley covered with leather, with the hair side of the belt turned to it, offers 50 per cent. more resistance to slipping than with a pulley merely polished. When a belt is turned with the hair side to pulley, the contact is greater, from the fact of a more even surface being presented, than when the flesh side is to the pulley; and, again, as the outside of a belt must necessarily stretch more in bending over a pulley, it follows that if the hair side is the outer one it will finally crack; but by reversing it, so that it must contract in wrapping around the pulley, it lays on with great smoothness, and the flesh side, being more open and irregular, experiences no difficulty or injury by the stretch from being outside.

Carders may gather from this, which is only corroborative of our daily experience, that their worker belts and pulleys

should be covered with leather, and the belts run thereon with the hair or grain side next the leather face of pulley. By covering as indicated, much power can be saved in a set of cards, and the belts will last longer, from not requiring to be so tightly stretched, and more work may be turned off by preventing the slipping. It is claimed, however, that, if belts are run with the flesh side to pulley, and tanner's dubbing applied thereto, they will become as smooth as the hair side, and will be greatly more durable. It is also well to remember that the pliableness of a belt has often more to do with its adhesiveness to the pulley than the question of which side shall be presented to it, and for that reason they should always be maintained as pliable as possible.

The strongest part of belt leather extends about one-third the way through from the flesh side.

It has been found that belts should not be run faster than 30 feet per second, nor endure a tension of over 300 pounds per square inch of section.

Belts, where it is possible, should always run from the top of the driving to the top of the driven pulley.

Pulleys should always be as large as possible, and of sufficient width, together with the belt, so as not to require excessive tension to get the required power.

Holes punched in the ends of belts should be oval in shape, with the largest diameter parallel with the length of belt, so as to cut out as little of the effective strength as possible. In lacing a belt draw all parts together equally, so that the strain will be distributed among the stitches, and not be concentrated on one stitch and hole, thereby pulling

apart in a short time. The crossings of the lace should always be on the outside of the belt, for if next the pulley they will very soon wear apart where crossed. Always begin the sewing of a belt in the centre, working towards each edge, keeping the edges square, and then returning into the centre again, where the ends of the lace can be fastened.

Belts always run to the high part of a pulley *when the shafts are parallel;* but when they are not, the belt will always run *toward the ends of the shafts* which are *nearest together*, and this tendency is *much stronger* than to run to the highest part of the pulley. If overseers would only apply this rule intelligently there would be an end of card belts sometimes running to the fast pulley, and again persisting in remaining on the loose pulley; and it would banish all the traps employed which rub and destroy the edge of the belts in a puerile attempt to force them against the mechanical laws by which they are governed.

If you have a belt which gives trouble in the way described, you can soon ascertain if it is the shafts, or either of them, by stretching a line across the edges of the two pulley faces, and if they are square it is the fault of one or the other of the pulleys, and can be remedied by putting a "leader" or narrow strip of leather in the centre of the faulty pulley. Sometimes the belt is so unreasonably tight as to spring the shaft, and that will also cause trouble. We give the following rule for ascertaining the driving horse-power of a belt, its velocity and square inches being known: —

Rule. — Divide the number of square inches of belt in

contact with the pulley by 2, multiply this quotient by the velocity of the belt in feet per minute, and this amount divided by 32,000 will give the horse-power.

Example. — A 20-inch belt moves 2,000 feet per minute; 6 feet of its length is in contact with the circumference of a 4-foot pulley; 20 multiplied by 72 equals 1,440; divided by 2 equals 720; multiplied by 2,000 equals 1,440,000; divided by 32,000 equals 45 horse-power.

This rule must not be considered as invariable, for the horse-power transmitted by a belt depends on the position of the shafts and pulleys, on the flexibility of the belt, on the amount of wrap on the pulley surface, the degree of pressure, and many other things. A belt wrapped one-quarter around a pulley has only one-fourth the power of a belt wrapped one-half around the same pulley.

Estimating the Velocities of Shafts, Pulleys, etc.

Rule. — *To find the speed of a driven shaft.* — Multiply the number of revolutions of driving shaft by the diameter of driving pulley in inches, and divide the product by the diameter of the driven pulley in inches.

Rule. — *To find the speed of last shaft where several shafts and pulleys intervene.* — Multiply all the drivers into each other and the product by the speed of the first shaft, which divide by the product of all the driven pulleys multiplied into each other.

Rule. — *To find the diameter of a driving pulley to give a desired number of revolutions to a driven shaft.* — Multiply the diameter of the driven pulley by the number of revolutions you wish it to make, and divide the product by

the revolutions of the driver; the quotient will be the required diameter of the driving pulley.

Rule. — *To find the diameter of a driven pulley giving a required number of revolutions to a driven shaft.* — Multiply the diameter of the driving pulley by its number of revolutions, and divide the product by the number of revolutions desired of the driven, and the quotient will be the required diameter of pulley.

Rule. — *To find the length of a driving-belt before the pulleys are in position.* — Add the circumference of the 2 pulleys, divide the product by 2, and add the quotient thus obtained to double the distance between the centres of the 2 shafts, which will give the length of belt required. For a cross belt add the circumference of the 2 pulleys, multiply the product by 3, and divide by 2; the quotient added to double the distance between centres of both shafts will give the length required.

Rule. — *To find where to cut belt-holes in floors.* — Measure the distance in inches from centre of driving shaft to underside of floor; on the upper side make a mark over the centre of shaft. Now measure the distance from centre of shaft on machine to be driven to floor, making a mark on the floor immediately beneath the centre, then measure the distance between the two marks. Transfer these figures to a board or paper, draw off the driving and driven pulleys after finding their diameters, at the distance from each other and the floor line previously obtained, and draw the lines representing the belt cutting the floor line, which will show where the belt passes through the floor. The drawing can be made to a scale to reduce it to convenient dimensions,

maintaining the proportions. The holes may now be marked off on the floor and cut with a certainty of being correct. In making the drawing it is best to do it full size on the floor, if room can be had; and allowance must be made for the thickness of the flooring.

Belt-dressing. — A good dressing may be made by the use of castor-oil mixed about half and half with tallow or other good oil. Castor-oil makes not only an excellent dressing, but renders the belts vermin-proof.

Water-proof glue. — Fine shreds of India-rubber dissolved in warm copal varnish make a water-proof cement for leather or wood.

Another cement is made by melting together equal parts of asphaltum and gutta-percha, and applying hot under a press.

Cement for belting. — American isinglass and good glue equal parts; add water just sufficient to cover the whole and place in a boiler (glue-pot); let them soak for ten hours, then bring to a boiling heat, and add pure tannin until the whole becomes ropy and in appearance similar to the whites of eggs. Buff the grain off the leather where it is to be cemented, and apply the cement warm, and rub the joined surfaces solidly together; then let it dry for a few hours and it is ready for practical use. If properly done it will make a very strong joint.

Test for Belting Leather. — A simple means for testing leather to ascertain the nature of the tanning to which it has been subjected, consists in steeping a cutting of the material about ⅛ inch thick in strong vinegar. If the leather has been properly tanned, and is therefore of good quality,

it will remain immersed for months without alteration, simply becoming a little darker in color. If, on the contrary, it is not well impregnated with the tanning, the fibres will quickly swell, and after a short period become transformed into a gelatinous mass.

Hints on Shafting.

TABLE, showing the Diameter, in Inches, of Wrought-Iron Shafts necessary to Transmit with Safety from 1 to 150 Horse-Power at from 10 to 1,000 Revolutions per Minute.

Horse-Power.	Revolutions per Minute.											
	10.	25.	50.	75.	100.	150.	200.	250.	300.	400.	500.	1,000.
1	3	2 1/4	1 3/4	1 1/2	1 3/8	1 1/4	1 1/8	1	1	7/8	7/8	3/4
2	3 3/4	2 3/4	2 1/4	2	1 3/4	1 1/2	1 3/8	1 1/4	1 1/4	1 1/8	1	7/8
3	4 1/4	3 1/4	2 1/2	2 1/4	2	1 3/4	1 1/2	1 3/8	1 3/8	1 1/4	1 1/8	1
4	4 3/4	3 1/2	2 3/4	2 1/2	2 1/4	1 7/8	1 3/4	1 1/2	1 1/2	1 3/8	1 1/4	1
5	5	3 3/4	3	2 3/4	2 3/8	2	1 7/8	1 3/4	1 3/4	1 1/2	1 3/8	1 1/8
10	6 1/4	4 3/4	3 3/4	3 1/4	3	2 1/2	2 1/4	2 1/4	2 1/8	1 7/8	1 3/4	1 3/8
15	7 1/4	5 1/4	4 1/4	3 3/4	3 1/2	3	2 3/4	2 1/2	2 3/8	2 1/4	2	1 5/8
20	8	5 3/4	4 3/4	4 1/4	3 3/4	3 1/4	3	2 3/4	2 6/8	2 3/8	2 1/4	1 3/4
30	9	6 3/4	5 1/4	4 3/4	4 1/4	3 3/4	3 3/8	3 1/4	3	2 3/4	2 1/2	2
40	10	7 1/2	5 3/4	5 1/4	4 3/4	4 1/4	3 3/4	3 1/2	3 1/4	3	2 3/4	2 1/4
50	..	8	6 1/4	5 1/2	5	4 1/2	4	3 3/4	3 1/2	3 1/4	3	2 3/8
60	..	8 1/2	6 3/4	5 3/4	5 1/1	4 3/4	4 1/4	4	3 3/4	3 3/8	3 1/4	2 1/2
70	..	9	7 1/4	6	5 1/2	5	4 1/2	4 1/8	4	3 1/2	3 3/8	2 5/8
80	..	9 1/4	7 1/2	6 1/2	6	5 1/4	4 3/4	4 1/4	4 1/8	3 3/4	3 1/2	2 3/4
90	..	9 3/4	7 3/4	6 3/4	6 1/8	5 1/2	5	4 1/2	4 1/4	3 7/8	3 5/8	2 7/8
100	..	10	8	7	6 1/4	5 3/4	5 1/8	4 3/4	4 3/8	4	3 3/4	3
110	..	..	8 1/4	7 1/4	6 1/2	6	5 1/4	4 7/8	4 1/2	4 1/8	3 7/8	3
120	..	..	8 1/2	7 1/2	6 3/4	6 1/8	5 3/8	5	4 3/4	4 1/4	4	3 1/8
130	..	..	8 3/4	7 3/4	7	6 1/4	5 1/2	5 1/4	4 7/8	4 1/2	4 1/8	3 1/4
150	..	..	9	8	7 1/4	6 1/2	5 3/4	5 1/2	5	4 3/4	4 1/4	3 1/2

How to cool a hot shaft. — A fancy will often get so hot as to necessitate the stoppage of the card, which might be

avoided in most cases as follows: Make a belt of something of a loose, water-absorbing nature, and hang it over the shaft as near the hot journal as possible, allowing it to hang down and run loose on the shaft. A pail of water may now be fixed so the lower part of the belt will run in it, and in this simple way the shaft may be cooled while running.

How to straighten a Crooked Shaft. — Set the shaft on blocks at each end, and under the hollow side make a fire, or apply sufficient heat to make the shaft hot. Now, with a swab, put water on the top, and the contraction will by repeated operations finally straighten the shaft.

The experiment was tried on a shaft 5 inches diameter, 12 feet long, and 3 inches out of line, the results of a fire, and it was brought in 2 hours perfectly straight.

Toothed Gears.

How to compute their velocities, etc. — The relative velocities of gears is as the number of their teeth.

Where "idle" or intermediate gears intervene they are not reckoned.

The pitch of a gear is the distance apart of the teeth from each other, and gears of unequal pitch cannot run together.

Bevel gears are employed for shafts fixed at various angles, and running at different velocities, governed by the respective bevels, which may vary in size, as with spur gearing.

Miter gears are those wherein both driver and driven are of equal diameter, and have their shafts fixed at right angles.

In computing the velocities of gear-wheels their diameters on the pitch line may be taken instead of the numbers of their teeth.

The pitch line of a gear is a circle struck from the centre, and passing through the middle of the teeth. It defines the diameter of a gear, which is not, as many suppose, the whole distance across from point to point of teeth, but half way from bottom to top of teeth.

To measure the diameter of a gear it is only necessary to take the distance from the bottom of the teeth on one side to the top of the teeth on the opposite side of the gear.

To ascertain the pitch of a gear. — Find the diameter as above, then count the teeth, and divide their number by the diameter.

Example. — If a gear of 21 teeth measures 3 inches diameter on the pitch line, then the gear is 7 pitch.

RULE. — *To find the number of teeth required in a wheel to have any given velocity.* — Multiply the velocity (number of turns per minute) of the driver by its number of teeth, divide the product by the number of revolutions desired, and the quotient will be the number of teeth for the wheel.

RULE. — *To find the velocity of a driven shaft.* — Multiply the number of revolutions of the driver by its number of teeth; divide the product by the number of teeth of the driven, and the quotient will be the revolutions.

RULE. — *To find the velocity of a driving-shaft.* — Multiply the number of teeth of the driven by its revolutions, and divide by the number of teeth of the driver; the quotient will be the velocity of the driving-shaft. Multiply the number of revolutions of driver by its number of

teeth, and divide the product by the number of teeth of the driven.

To ascertain the number of revolutions of a driver, when the revolutions of driven and teeth, or diameter of driver and driven, are given. — Multiply the number of teeth or the diameter of driven by its revolutions, and divide the product by the number of teeth, or the diameter of driver.

To ascertain the number of revolutions of the last wheel at the end of a train of spur-wheels, all of which are in a line and mesh into one another. — Multiply the revolutions of first wheel by its number of teeth, and divide the product by the number of teeth of the last wheel; the result is its number of revolutions.

RULE. — *To ascertain the number of teeth in each wheel for a train of spur-wheels, each to have a given velocity.* — Multiply the number of revolutions of the driving-wheel by its number of teeth, and divide the product by the number of revolutions each wheel is to make, to ascertain the number of teeth required for each.

RULE. — *To find the number of revolutions of the last wheel of a train of whe.ls, and pinions, spurs, or bevels, when the revolutions of the first, or driver, and the diameter, or the number of teeth or circumference of all the drivers and pinions, are given.* — Multiply the diameter, the circumference, or the number of the teeth of all the driving wheels together, and this continued product by the number of revolutions of the first wheel, and divide this product by the continued product of the diameter, the circumference, or the number of teeth of all the pinions, and the quotient will be the number of revolutions of the last wheel.

Example: If the diameters, the circumferences, or the number of teeth of a train of wheels are 8, 8, 10, 12, and 6, and the diameters, circumferences, or number of teeth of the pinions are 4, 5, 5, 5 and 6, and the driver have 10 revolutions, what will be the number of revolutions for the last pinion? Multiply all the drivers together, and then by 10 revolutions, and you have $8 \times 8 \times 10 \times 12 \times 6 \times 10 = 460{,}800$; divide this amount by the product of the figures for pinions, $4 \times 5 \times 5 \times 5 \times 6 = 3{,}000$, and the quotient will be 153, or the number of revolutions of last wheel.

For ascertaining the Size of Woollen Yarn and Slubbing. — Scales of various kinds are in use for this purpose, and a brief description may be given of several of the most popular ones.

Quadrant Scales. — These are simple, convenient, and accurate. The skein is put into the pan, when the pointer indicates the number of the yarn by pointing to the figure on a graduated scale.

Troy Grain Scales. — These have the beam of an ordinary scale, with small brass pans suspended from each end of the beam and balanced. The yarn is placed in one pan, and the grains or pennyweights in the other. They will weigh from ½ grain to 393½ grains.

Lever-Beam Scale. — This is a long brass beam, graduated for different lengths of yarn or roving, but usually for 50 yards, and numbered for "cuts" or for "runs," as desired. They are the most convenient of any, and sufficiently accurate so long as they are not tampered with; but in some cases the end of the beam has been filed, and in that case it gives a fictitious value to the yarn, showing it to be finer

than it really is. There are no weights, and it is only necessary to reel off the number of yards indicated on the weighted end of the beam, and then suspend it by a single thread at that point where it brings the beam into equilibrium, and the nearest figure indicates the size.

Grain Roving Scale. — These are intended to be more accurate than the others, and, if right, they will weigh to the tenth part of a grain. The beam is graduated into 100 parts (grains), and has a small sliding weight. At the end there is a small hook to receive other weights if the sliding weight is not sufficient; these are numbered 100, 200, 400, 800, and anything from 1 to 1,600 grains can be weighed.

It is a very necessary thing to have the scales right, whichever kind is used; still we have seen carders' and spinners' scales, although both of the same kind, in the same mill, at variance. There are many mills where both carders' and spinners' scales have been "fixed" to correspond, and where a "run" is only a name without significance. We have taken yarn, just as weighed in one mill, to another in same town, and found a difference of 20 per cent. in the indications. While this is the case we can form no idea of the true size of the yarn.

As Troy weight is the base of calculation for woollen yarn, we herewith append it for reference: —

TROY WEIGHT.

24 grains	make	1 pennyweight.
20 pennyweights	"	1 ounce.
12 ounces	"	1 pound.

gr.	pwt.		
24 =	1	oz.	
480 =	20 =	1	lb.
5,760 =	240 =	12 =	1.

7,000 grains Troy make 1 pound Avoirdupois.

It is just as important to *carefully* measure the required length of yarn as it is to have the scales right; for it is quite easy to measure the same yarn twice, and *make* it vary 15 per cent. To measure the slubbing is a still more difficult matter, on account of its tender nature; and it requires care to perform the operation every time alike as nearly as possible, to avoid being continually led astray. Perhaps as good a way as any is, to run off from the condenser spool, by its own weight on to the floor, as much slubbing as you think will give the length. Break it off square across without stretching, then hold it against a post in which two marks have been made, three feet apart, at a convenient height, and allowing the slubbings to hang gently by their own weight, parallel with each other, break them off at the lower point marked on the post, being careful to do so without slipping up on it, and also seeing that the top end is always the same at the mark, not a little below it. The rovings or slubbings are usually made (on fair work) half the size of the intended yarn; that is to say, 2½-run slubbing for 5-run yarn, which would give a little more than halt draft, because the slubbing is measured loose and the yarn tight.

In estimating the size of yarn different terms are used in

different localities to indicate its proportionate length and weight, as follows: —

YARN MEASURE.

	1 knot	=	80 yards,			1 lb.
	$3\frac{3}{4}$ "	=	300 "		1 cut.	1 "
$5\frac{1}{3}$ cuts	= 20 "	=	1,600 "		1 run.	1 "

The standard of woollen yarn is 100 yards, weighing 1 ounce Avoirdupois, or $437\frac{1}{2}$ grains Troy, or 1,600 yards of 1 run yarn to the pound; in other words, —

1 run is 1,600 yards to the pound.
2 " 3,200 " " "
$2\frac{1}{2}$ " 4,000 " " " etc.

Or, if "cuts" instead of runs are employed, then, —

1 cut is 300 yards to the pound.
2 " 600 " " " etc.

RULE. — *To find the number of runs.* — Multiply the length in yards by 7,000, the number of grains in one pound, and divide by 1,600; divide the quotient thus obtained by the weight in grains, which will give the runs. Or, multiply the yards by $4\frac{3}{8}$, and divide by the number of grains.

RULE. — *To find the number of cuts.* — Multiply the length in yards by $23\frac{1}{3}$, and divide by the number of grains it weighs.

By having either a spinner's table for reference, with Troy scales and weights, or one of the graduated beams, a ready means is provided, which saves calculating, and is the plan in use everywhere. We here append a yarn table, instead of a lot of formulas, for estimating the size by calculation. These tables answer for either slubbing or yarn.

WOOLLEN YARN TABLE.

Calculated for 20 yards Woollen Yarn.

Grains.	Runs.	Grains.	Runs.	Grains.	Runs.
1	87.50	12	7.29	34	2.57
1½	58.33	13	6.73	36	2.43
2	43.75	14	6.25	38	2.30
2½	35	15	5.83	40	2.19
3	29 16	16	5.47	42	2.08
3½	25	17	5.15	44	1.98
4	21.88	18	4.87	46	1.90
4½	19.44	19	4.60	48	1.82
5	17.50	20	4.38	50	1.75
5½	15.90	21	4.16	52	1.68
6	14.58	22	3.98	54	1.62
6½	13.46	23	3.80	56	1.56
7	12.50	24	3.65	58	1.50
7½	11.66	25	3.50	60	1.46
8	10.93	26	3.37	62	1.41
8½	10.30	27	3.24	64	1.37
9	9.72	28	3.13	66	1.32
9½	9.20	29	3.02	68	1.28
10	8.75	30	2.92	70	1.25
11	7.95	32	2.73	88	1.00

N.B.—Reel 20 yards, and against its weight in grains willbe found the Run.

TABLE, calculated for 100 yards of Woollen Yarn.

Runs.	Grains.	Runs.	Grains.	Runs.	Grains.
1	437.50	6	72.91	11	39.77
1¼	350.	6¼	70.	11¼	38.88
1½	291.66	6½	67.30	11½	38.04
1¾	250.	6¾	64.81	11¾	37.24
2	218.75	7	62.50	12	36.45
2¼	194.44	7¼	60.34	12¼	35.71
2½	175.	7½	58.33	12½	35.
2¾	159.09	7¾	56.45	12¾	34.31
3	145.83	8	54.68	13	33.65
3¼	134.61	8¼	53.03	13¼	33.02
3½	125	8½	51.47	13½	32.40
3¾	116.66	8¾	50.	13¾	31.80
4	109.37	9	48.61	14	31.25
4¼	102.94	9¼	47.29	14½	30.17
4½	97.22	9½	46 05	15	29.16
4¾	92.10	9¾	44.87	15½	28.22
5	87.50	10	43.75	16	27.34
5¼	83.33	10¼	42.58	16½	26 51
5½	79.54	10½	41.66	17	25.74
5¾	76.08	10¾	40.70	17½	25.

CHAPTER II.

HISTORICAL REVIEW AND PROGRESS OF INVENTION.

The arts to which our present subject applies have been practised from a very early period of the world's history; for it is recorded so long ago as 1700 years before the Christian era, that Pharaoh arrayed himself in vestures of fine linen. In a book written by Confucius 2,300 years ago he orders, with the greatest minuteness, the rules to be observed in the manufacture of silk which in Europe so late as the reign of the Emperor Aurelian was worth its weight in gold, and we are told that his empress had to forego the luxury of a silk dress on account of its great cost.

According to Pliny, Semiramis, the Assyrian queen, first invented weaving; and in some of the ancient statues Minerva is represented with the distaff, indicating that she taught the art of spinning. The Mohammedans give the credit to a son of Japhet; the Egyptians to their goddess Isis, whom they adored as the great benefactress of their country; the Chinese attribute the invention to the consort of their Emperor Yao, and in all the ancient countries the honor is attributed exclusively to their queens and princesses.

Homer, the Grecian poet, 1,000 years B.C. writes in Book III.:—

> "Her country, parents, all that once were dear,
> Rush to her thought, and force a tender tear.

O'er her fair face a snowy veil she threw,
And, softly sighing, from the loom withdrew.

. . . .

(Like fair Laodicè in form and face,
The loveliest nymph of Priam's royal race:)
Her in the palace, at the loom, she found;
The golden web her own sad story crowned,
The Trojan wars she weaved (herself the prize)
And the due triumphs of her fatal eyes."

And the Roman poet Virgil, B.C. 50, advises:—

"If the woollen manufacture be thy care, first let prickly woods, and burs, and caltrops be far away; shun rich pastures; and from the beginning choose flocks that are white with soft wool. And that ram, though he himself be of the purest white, under whose moist palate there lurks but a black tongue, reject, less he should sully the fleeces of the new-born lambs; and look out for another over the well-stocked field."

That the woollen manufacture was actually carried on with some sort of machinery is shown by the following extract from a recent publication:—

"One of the latest discoveries in Pompeii is a small woollen manufactory, situated very near the house where the fresco representing Orpheus was recently discovered. Several charred fragments of tapestry were found in this place, besides various machines for carding and weaving wool."

By the revised code of laws for the Roman empire, published A.D. 533, a monopoly in the manufacture of silk was given to the court, and looms worked by women were erected in the imperial palace.

Benjamin, of Tudela, writing in 1161, says that the City of Thebes contained about 2,000 Jewish inhabitants, and that "these are the most eminent manufacturers of silk and purple cloth in all Greece."

Cloth of gold was one of the earliest fabrics manufactured; and we read that when Pope Paschal, A.D. 821, sought for the body of St. Cecily, who was martyred A.D. 230, the pontiff found the body in the Catacombs, whole, and dressed in a garment wrought all of gold, with some of her raiment drenched in blood at her feet. Childeric, the second king of the Merovingian dynasty, was buried A.D. 482, at Tournai. In 1653 his grave was discovered, and in the earth about it many remains of this textile made of pure gold, the threads of which were flat instead of round. A "gowne of cloth-of-gold, furred with pawmpilyon, ayenst Corpus Xpi day" was bought for Elizabeth of York, afterwards the queen of Henry the Seventh; and it is on record that Queen Mary, thirteen years before she came to the throne, "payed to Peycocke, of London, for XIX yerds iii. qr̃t of clothe of golde at xxxviij.s̃ the yerde, xxxvij*li*. x*s*. vj*d*" and for "a yerde and dᶟ qr̃t of clothe of siluer xl*s*."

Different modifications of hand-looms were in use in ancient times for weaving. The Egyptians wove in an upright loom, and beginning at the top, so as to weave downwards, sat at their work. In Palestine the loom was also upright; but the weaver, beginning at the bottom and weaving upwards, was obliged to stand. There was also the horizontal loom, some of which were sold in London, together with some "staves," shuttles," and a "slay," in 1316, to Simon Abbot, of Ramsay, "pro weblomes emptis xx^{s}. Et pro staves ad easdem vj^{d}. Item pro iiij shittles, pro eodum opere ij^{s} vj^{d}. Item in j slay pro textoribus viij^{d}." And Chaucer mentions among his pilgrims in the prologue,

> "An haberdasher and a carpenter,
> A webbe, a dyer, and a tapaisser."

The manufacture of cloth was introduced into England in the reign of Henry II., between the years 1100 and 1130, when a colony of Flemish artisans left their own country to escape the persecutions of the guilds, who, for violation of their oppressive edicts, drove the weavers from their homes, and burnt their property.

Edward III., from 1327 to 1377, encouraged this emigration into England, and sent agents among the dissatisfied people, who offered liberal inducements to them to come and teach the English their handicraft. Great numbers of these people came over and settled in London, Yorkshire, Lancashire, and Nottingham. John Kemp, whom we have before mentioned as having received a patent from the government to practise and teach his art, settled at Kendall, where some of his descendants still live. William and Hankemus de Brabant settled at York, and three brothers, by name of Blanket, at Bristol, from which circumstances we derive the names of "Hanks" and "Blanket."

Worsted, a town in Norfolk, by a new method of its own, commenced about the same time the manufacture which still retains the name of its ancient birthplace. The cloth became celebrated, and we read that in 1356 Elizabeth de Bohun bequeathed to her daughter, the Countess of Arundel, "a bed of red worsted embroidered."

Laws of various kinds, restrictive or prohibitory, were passed, with the object of fostering the trade, especially by Edward III., who was as rampant a protectionist as any of the present day. But no sooner had the trade become fixed,

and English cloth become known abroad as of sterling quality, than the cupidity of men, in their haste to become rich, led to adulteration, which ended in almost ruining the trade.

At this time all English cloth had to be sent to Belgium and Holland to be dyed; but William Cholmley tried experiments with the water of the Thames, and discovered that it, contrary to the general belief, would answer as well as the water in Holland; and he imported a number of Flemish dyers to teach his own servants the secrets of their art, which, after mastering, he offered through the government to his countrymen.

About the year 1485 the trade was established at Halifax, and a few years later a law was passed to protect the tradesmen from pilferers, who stole their cloth at night. It was enacted that whoever was found with stolen cloth in his hands, or on his back, or who confessed to having stolen any, if the value exceeded 13½ pence, he should be hung on the gibbet in the market-place. Hull being also a hard place for violators of the law, we find that the thieves of that time sang, —

> "From Hull, Hell, and Halifax,
> Good Lord, deliver us."

Despite the protective laws, and consequent monopolies, the trade languished, and in the midst of it, in 1662, a public memorial stated that a single branch in the trade had decreased from 100,000 pieces to 11,000 pieces.

A great impetus was given to the woollen-cloth trade in 1672 by the emigration and settlement in England of Hu-

guenot merchants, manufacturers, and artisans. It is computed that 100,000 French workmen fled into England in consequence of the revocation of the Edict of Nantes in 1672, although the penalty of their arrest was death or the galleys for life. Leaving everything behind them, these people arrived in England poor; but they were given a hearty welcome by the English people, who raised a subscription of £200,000 ($1,000,000) for their relief. The influx of these Protestant refugees introduced the manufacture of buttons, beaver hats, calico-printing, but more particularly the manufacture of silk, which the English government had several times before tried to introduce from France.

The prohibitory restrictions against the export of English wool, and a duty of sixpence per pound on foreign wool, raised the price of the raw material so high that Spanish wool was worth five shillings, and Saxony eight to ten shillings per pound; the result being that the manufacturers were confined to native wools totally unfit for fine goods, which, if made at all, became greatly enhanced in price; this, while adding a fictitious value to the product of the land-owners, greatly harassed the manufacturers, who, so late as 1824, by some strange hallucination, actually joined the agriculturists in maintenance of these obnoxious tariffs, which for 100 years had restricted the trade and obstructed the progress of invention, as was clearly proved afterwards.

The Norfolk spinners, in early times, spun their yarn by a dexterous and patient twisting of the thread upon the thigh. Then came the single-thread wheel, which left one

hand at liberty to draw out the thread, and greatly facilitated the length of yarn produced. This continued until Wyatt's great invention of spinning with rollers, and his fitting up of a machine at Birmingham. The motive-power which he employed was two asses, hitched to a "gin;" and ten girls were employed to operate the new invention.

Such was the beginning of our present textile industries, and the commencement of that era of invention in the midst of which we are at the present time. For originality and pregnant consequence Wyatt's invention stands alone; all the other great leaps in invention, such as the steam-engine of Watt, and the locomotive of Stephenson, have followed the "Spinning Engine without Hands" of Wyatt, as a natural consequence of it.

We will now place before the reader of this deeply instructive subject the various inventions, in their chronological order, which have, more perhaps than anything else, contributed to the comforts and civilization we now enjoy. In this category we shall give the dates, numbers of the patents, names of inventors, and titles, as complete as we have been able to get at them. A perusal of them will give to any one connected with textile affairs an excellent idea of the progress of invention, and a careful study of these facts often points the way to future improvement.

The dates, etc., will also do for reference, and they can be relied upon, as I have verified most of them myself, and examined the patents to which they refer.

1664. — The first *Textile* invention of which we have record was the subject of a patent issued to Abraham Hill, March 3, 1664, No. 143, for "an instrument or an engin for

breaking of hemp and flaxe, and dressing the same in a new waye; as also for washing of all sorts of linnen."

1678.—Richard Dereham and Richard Haines obtained the next patent, April 18, 1678, No. 202. "A new spining engin never used in England, whereby from six to an hundred spinners and upwards may be employed by the strength of one or two p̃sons to spin linnen, and worsted thread with such ease and advantage, that a child of five or foure yeares of age may doe as much as a childe of seven or eight years old, and others as much in two days as without this, their invenc̃on, they can in three dayes."

1681.—John Joachim Becher was the next to appeal for protection by royal patent, and the privilege was granted him under date of Aug. 2, 1681, No. 213, to exclusively own his invention for a "new waye or instrument for the *winding of silke.*"

1692.—Ralph Marshall and John Englebert Teshmaker obtained the next patent under date of Jan. 11, 1692, No. 286, for "a new invention never practiced here before," for the "making of *spinall yarne.*"

Teshmaker assigned the whole of his rights in the above patent, on the 22d of the following month, to his partner, Marshall, thus making, probably, the first assignment of such property.

1692.—Charles Moreton and Samuel Weale secured a patent for the invention of a Beater, Jan. 22, 1692, No. 288, and they show "a new machine or engine useful for beating, pounding, and stamping all sorts of mineral ores and Hemp and flax."

1718.—Thomas Lombe patented several new devices,

Sept. 9th, 1718, No. 422, and relates he has "found out and brought to perfec͠con three sort of engines," — "one to *wind* the finest raw silk, another to *spin*, and the other to *twist* the finest Italian raw silk into orgazine in great perfec͠con which was never before done in this our kingdom."

1723. — ISAAC MILLS appears as the first to conceive a machine for *pressing* and *finishing*, for which he secured a patent, June 27, 1723, No. 456, for "two instruments of iron to be vsed in the said trade of woll kombing and pressing which are caste in such a forme and contrived in such a manner that a fire being made in the body of the instrument of the iron for kembing, the kembs receive the heat from the same in such an equal propor͠con as neither to neal the kembs or burn the woll; and that for the pressing, the planks or plates being placed in the body of the other iron instrument and a fire being made to encompass or surround the same will heat the plate or plates in so true a degree as wholly to prevent the burning of the goods and the great loss frequently sustained by the trade in the woolen manufacture thereby."

1725. — THOMAS TEETON obtained a patent Dec. 15, 1725, No. 482, for "an engine or machine called a straiter, for the better and more easy perfecting the throwing and manufacture of all sorts of fine, single and double raw silk."

1729. — MARTIN BEDWELL's patent, April 19, 1729, No. 508, first mentions weaving, but it is not a machine intended strictly for weaving, as appears from his claim for "a new engine for spinning, working and weaving of hemp, flax, and hair, by a more easy and different method than has hitherto been found out."

1730–1733. — John Kay's first patent was for a sort of twister and carder for mohair and worsted, and is dated May 8, 1730, No. 515. His next patent covers a machine for opening and dressing wool, and also a claim covering the *fly shuttle*, this being therefore the first patent for a shuttle for weaving, and it is dated May 26, 1733, No. 542. This remarkable invention is thus described by him: "and that he hath likewise found out and contrived a newly invented shuttle, for the better and more exact weaving of broad-cloths, broad-bays, sail-cloths or any other broad goods, woolen or linnen, which shuttle is much lighter than the former, and by running on four wheels moves over the lower side of the webb spring, on a board put under the same, and fastened to the layer, and which new contrived shuttle, by the two wooden tenders, invented for that purpose, and hung to the layer, and a small cord commanded by the hand of the weaver, sitting in the middle of the loom, with great ease and expedition, by a small pull at the cord, casts, or moves the said new invented shuttle, from side to side at pleasure, and also strikes the layer, by his pulling it in the middle, uniformly over the piece, making it unavoidably even, and much truer and better than any method hitherto used."

The reader who has not seen the identical arrangement exactly as he described it will no doubt believe every word that he says in favor of his invention. It is the very loom our mothers worked on but yesterday, and hundreds are still to be found scattered among the farm-houses of the Western States.

1738. — John Wyatt, of Lichfield, had worked out what he termed "a spinning engine without hands;" but the great

difficulties he necessarily met with baffled him, and from those causes he seems to have finally given way to LEWIS PAUL, who patented WYATT's machine June 24, 1738, No. 562. The issue of this patent signalled the doom of the "domestic manufacture" throughout the world; and when we read the specification in which they sought to make their invention plain, we are astonished at the intuitive conception which so clearly pointed out the principle upon which spinning machines have ever since been constructed. They tell us that it is a new system of spinning by means of "rowlers, cillinders, or cones," and that the amount of draw is proportional to the relative velocity of these several sets of "rowlers, cillinders, and cones."

1748. — DANIEL BOURNE patented the *Carding Engine* Jan. 20, 1748, No. 628, and he describes perfectly the carding machine as at present constructed; the changes since have been in the details rather than affecting the principles or elements of the machine, which Daniel so well explained. (See "The Carding Engine.")

LEWIS PAUL, in August of the same year, patented a *flat surface card*, of no value.

1750. — WILLIAM PENNINGTON obtained a patent for a *card-making* machine Oct. 13, 1750, No. 657, which perforated the holes in the leather at uniform distances apart by a graduated dividing wheel.

1754. — The next patent was to JAMES TAYLOR, July 3, 1754, No. 693, which clearly describes for the first time a method of spinning "from the *spindle point*" "to the barrell short reel or long reel as occasion may require."

1758. — LEWIS PAUL obtained a third patent June 29, 1758,

No. 726, showing clearly the *flyer* attached to the spindle, a conical bottom loose on the spindle, and a contrivance to *build* an even, regular bobbin. He also shows how to operate the spindles by friction wheels, and also a *stop motion* worked by hand, which simultaneously stops the spindle and rolls, and concludes by saying, "This command of spindle and cylinder is of very great importance every time a thread breaks or that the bobbins have their apportionment."

1760. — Robert Kay, son of the inventor of the fly-shuttle, patented the drop-box for looms in 1760.

1769. — Richard Arkwright obtained his first patent July 3, 1769, No. 931, and he describes a series of *pairs of rolls* drawing the sliver by one pair running faster than another, the top rollers being weighted; twisting the thread by means of wooden flyers, with wire arms for correctly guiding the thread on the bobbins, and driving the latter with *worsted bands*, "the screwing of which, tight or easy, causes the bobbins to wind up the thread faster or slower."

James Watt obtained his first patent on the Steam Engine in 1769, but it was nothing more than a water-pumping engine, not capable of "giving motion to the wheels of mills or other machines" until he added his further improvements, secured to him by patent granted in 1781.

1770. — James Hargreaves obtained his first patent June 12, 1770, No. 962, for a spinning machine which is "to be managed by one person only, and that the wheel or engine, will spin, draw and twist sixteen or more threads at one time by a turn or motion of one hand and a draw of the other." He also shows a roping or slubbing gauge, and says, "These stops gauge a proper length of slubbin to spin at one draw,

and are likewise moveable in slots as occasion may require to spin to any proper degree of fineness."

1775.—RICHARD ARKWRIGHT's second patent is dated Dec. 16, 1775, No. 1111, in which he describes a preparing machine to bring the cotton into shape for the carding machine "which hath *fillet cards*," and from which the material is detached by a *doffing comb*, from whence it passes to a machine having two pairs of rollers; the second, having a quicker motion than the first pair, draws it to the fineness required. Over and under the drawing rolls he shows revolving circular brushes for keeping the rollers clean; and among several other machines he shows one having a bobbin and flyer, wherein the motion of the bobbin can be quickened or slackened by means of a *conical drum*. He also shows a *clutch* on the driving-shaft, which by a lever can be disengaged from the pulley, and stop the machine. In this patent ARKWRIGHT covered several things which were subsequently claimed by others. JOHN LEES claims that he invented the feed for cards in 1772, and HARGREAVES insisted that he originated the idea of the *doffer* comb covered in ARKWRIGHT's patent.

1776.—THOMAS WOOD patented the clothing of a doffer *spirally*, so as to obtain a continuous sliver, in 1776.

CROMPTON, five years after HARGREAVES had invented the Jenny, took the machine and added to it the rolls of ARKWRIGHT, thus creating the *spinning mule*. CROMPTON worked on this invention from 1774 to 1779, and he failed to patent it; but Parliament, in view of its importance, granted him £5,000.

Henry Marsland patented the *rising and falling rail* for spinning machinery, June 26, 1776, No. 1126.

1779. — Richard March obtained a patent for a card and spinning machine combined, Nov. 15, 1779, No. 1236, so as to spin *direct from the card;* and this idea "still goes marching on," for we have just seen in a monthly technical journal a description of the latest style of Mr. March's card-spinner, which this time emanates from Germany.

Robert Peele patented the *side drawing tube* and the *tin "kans"* now found in every mill, Feb. 18, 1779, No. 1212: "a tube or funnel near the doffer for drawing off, and slightly twisting the sliver."

1784. — Henry Richardson obtained a patent Sept. 11, 1784, No. 1450, for *covering* the top rolls of spinning machines with *leather.*

1785. — Arkwright's patents declared void.

1786. — John Boyds, an inventor whose name is not familiar to many, obtained a patent for *winding by surface contact*, in November, 1786.

It would be difficult to name a principle now more universally applied in the textile industries than this, and yet the originator of it is scarcely ever named. It is an invention of such vast importance, that, if it could be removed or obliterated, it would instantly stop every industry engaged in textile manufacturing throughout the world.

1790. — Dr. Edmund Cartwright obtained his first patent on the *power loom* April 27, 1790, No. 1747; second, Dec. 11, same year, No. 1787; third, May 15, 1792, No. 1876; and, fourthly, the Government merged the whole of the others into patent No. 2524, July 2, 1801. The object was

merely to bring Dr. Cartwright's scattered inventions together, so as to be more accessible, and consequently of more benefit, to those interested in the subject.

1792. — William Kelley, May 15, 1792, obtained patent No. 1879 for making the "billey," "jenny," etc., self-operating.

1794. — Whitney's Cotton Gin was patented March 14, 1794, in the United States, and stands as the most valuable invention which ever sprang from this country of invention. Its value was *priceless.*

1799. — Clement Sharp and Amos Whittemore, in British patent No. 2322, June 26, 1799, patented the complete *Card-setting machine*, which is more fully described in another part of this book.

1801. — Marie Joseph Jacquard, the inventor of the *figure-loom*, which by a simple mechanical operation determines the movements of the threads in the warp which form the pattern, thereby dispensing with the "draw-boy," completed his invention Dec., 1801, but refused to secure it by patent, as he desired to benefit the weavers of Lyons, who, for his disinterestedness, smashed his looms in front of his own door, and threatened to set the house on fire.

1802. — *The rotary shearing machine* was brought out in the west of England.

1804. — Ratcliffe, in England, patented the first *warp-dressing machine.*

1812. — *Rotary Gig* introduced.

1813. — *Shoddy* successfully manufactured; and *Mungo* in 1834.

1823. — William Lister patented the *combing machine*

Jan. 16, 1823, No. 4748, together with some 20 other patents subsequently.

1825. — Richard Roberts, of Manchester, patented the *self-acting mule*, March 29, 1825, No. 5138, and clearly defines his mechanism for making the mule self-operating. His *radial arm*, or *sector*, patented 1832, made the mule adapted for wool-spinning.

1825–1826. — Hale, of Haverhill, Mass., patented the *Ring doffers* in 1825, and afterwards sold it to John Goulding, who obtained a combination patent covering double ring doffers, tubes, and side-drawing devices, May 2, 1826, No. 5355. This patent covered the tube *condenser*.

1846. — Jessie Heilman's patent for his improved combing apparatus bears date Feb. 25, 1846, No. 11,103.

SKETCH OF THE EARLY TEXTILE INDUSTRY OF AMERICA.

Samuel Slater, as is well known, first introduced machinery into the United States for the manufacture of cotton into cloth. He landed here in 1789, with plans of the machinery, on the Arkwright system, concealed upon his person. Slater had worked in one of Arkwright's mills, and had helped in the construction of some of the latter's newly invented machinery. After many disappointments Slater finally got the first successful cotton mill in America started in 1791, but the machinery was necessarily of the crudest description.

John and Arthur Scholfield landed in Boston in May, 1793, from Yorkshire, and took up their residence in

Charlestown, Mass., until August of same year. Having introduced themselves to Mr. Jedidiah Morse, author of "Morse's Geography and Gazetteer," as being well versed in the manufacture of wool, Mr. Morse introduced them to wealthy residents of Newburyport, Mass., who undertook to put up a factory building at Byfield, in the vicinity of Newburyport. Here the Scholfields constructed the first *wool*-carding machine in America. This was first operated by hand before the building was ready to receive it. When all the machinery was constructed according to their direction, the factory went into operation, John Scholfield being employed as agent, and the business was conducted prosperously. John also started the first woollen mill in Conn., in 1798, and another in 1806.

Arthur Scholfield settled at Pittsfield, Mass., in 1800, and the following year started a roll card there, and built cards for sale to others, who started roll-carding mills in various places. From an interesting advertisement of that period we quote: —

"PITTSFIELD FACTORY, 1806.

"Double carding-machines, made and sold by A. Scholfield, for $253 each, without the cards (clothing), or $400 including the cards. Picking-machines at $30 each. Wool-carding on same terms as last year, viz., white, eight cents per pound, and twelve and a half cents for mixed."

From this and other advertisements of that period it appears that only roll-carding was carried on, and such establishments were springing up in many places. Mason Village, N.H., had one in 1800; New Ipswich, N.H., one in

1801; Worcester, Mass., one in 1803; and one started at North Amherst the same year; Hadley, Mass., had one in 1805; and, in 1809, Daniel Day built his first mill at Uxbridge, Mass., for the same purpose, viz.: the making of rolls for the domestic spinning-wheel; but in 1811 he put in a billy and a jenny for spinning. It is related of A. Scholfield, that, in 1808, he selected wool from the fleeces of merino sheep brought to this country a few years before, and made thirteen yards of black broadcloth, which were presented to James Madison, from which his inaugural suit was made. But it is not stated whether he had any spinner but the wheel; nor does it appear whether Daniel Day's jenny and billy, just mentioned, were the first. Earl & Williams were building cotton and woollen machinery at Worcester, Mass., previous to 1812; and when John Goulding went to learn the trade with them, in that year, they were making both billies and jennies.

John Goulding was born at Shrewsbury, Mass., in 1792, and seems to have assisted in the domestic manufacture from an early age. In 1812, when twenty, he "let himself" (as he puts it) to Messrs. Earl & Williams, and when with them but three months he was sent to New Jersey in charge of a set of cards, billy, and jenny, all of which he set up and started. On his return he tried some experiments with the object of applying power to the jenny, and thought also of applying it to the billy. After working only nine months at this trade he felt qualified to set up as machine-builder, and did so at Chelmsford, where he rented a place, and here he carded wool rolls, spun cotton, and built both cotton and woollen machinery. He also continued his experiments

in the application of power to the billy and jenny, but with apparently no practical results. Moving to Halifax, Mass., in 1820, he acted as agent for the company owning the mill, and here began to experiment with the object of "getting rid of the billy, and the short rolls." These are Goulding's words; so it would seem that he was already in search of the *condensing* principle. While acting as agent, these experiments were conducted solely on his own account; and as the machines were often stopped for his convenience, the clashing of interests seems to have finally interfered with his plans; so, at the end of some two or three years, he quit, and rented the Bussey Mill at Dedham, Mass. Here he manufactured broadcloth, built machinery, and continued the experiments that eventuated in the original condenser. Thinking his plan sufficiently developed to warrant his taking out letters-patent, but wishing to visit England and France, apparently for the purpose of learning what was being done there, and to apply for letters-patent in one or both countries, he sold out to Bussey early in 1826, went to Europe, left his application for British patent pending, and, on his return, obtained his first American patent in December, 1826. A large proportion of those who are connected with the woollen business, in one way or another, will say that Goulding did not invent the condenser; but when the attempt to prove that statement was made, at the great trial, it failed utterly. They had not been able to distinguish between Goulding's plan for getting rid of the "billy" and the slubbing process, and the plan put forth by others for simply doing away with the "piecers" of the short rolls, by adopting ring-doffers, having rings

3 inches wide, for making continuous or endless *rolls.* Two patents had been taken out for this purpose, one in 1824, the other in 1825; but both these inventors contemplated the retention of the "billy," while to "condense" means to annihilate the billy altogether. There is, therefore, no just comparison between the systems patented before Goulding's, and that which he patented. It is quite true that Goulding was not the first to patent ring-doffers, for one Arnold, of Pawtucket, R.I., claimed to have invented a pair of ring-doffers in 1812; and the zigzag ring-doffer was patented in 1824. Hale, of Haverhill, Mass., obtained a patent for two ring-doffers in 1825, and he is the recognized inventor; and it was this patent which Goulding bought, and further improved.

It is also true that Goulding did not originate the idea of "winding by surface contact," as in winding side-drawing, condenser, and other spools, — a mode of winding that was first patented in 1786 in England. All this is true enough; but it is quite as true that the world is indebted to John Goulding for the origination and realization of the idea that underlies this whole system. But he did not rest his claim to this invention upon these or any other *elemental* parts of his system, as is quite evident from his specification, as follows: "I do not claim the construction of the individual parts of the machinery used in the several processes before described, but the combination and arrangement by which they are made to produce thread from wool, or other fibrous material, by a continuous operation."

After his return from England, in 1826, Goulding again

settled in Dedham, Mass., remaining there about four years, building machinery, manufacturing flannels, etc. The next three years were spent at Boston Neck; then he went to Roxbury where he engaged in the manufacture of bale-rope from hemp; but, becoming bankrupt, in 1837 he went to New Albany, Ind.; next to Louisville, Ky., where he remained till 1844; then to Somerville, N.J., where he built machines he himself used in the manufacture of duck from hemp; but three years later he removed to Millbury, Mass., and went to manufacturing satinets, and after leaving there had no regular abiding-place till 1863, when he finally settled at Worcester, Mass. All this time he was almost constantly inventing and taking out patents, some of which may be enumerated, as: loom shuttle, 1827; washing machine, 1827; composition to start grease in wool, 1827; carpet loom, 1830; making dry steam, 1834; boiler for evaporating fluids, 1834; flax, hemp, and tow hackling, 1835; steam pipes, 1835; improvements in cotton gin and burring machine, 1860; improvements in breach-loading fire-arms, 1864; improvements in burring wool and ginning cotton, 1864. During the same period quite a number of patents were taken out by him in this country and in Europe which are not found in this list; but, incomplete as it is, it shows that he was a prolific inventor; and the story of his life, should it ever be faithfully written, will show that if his numerous inventions did not yield him the wealth he probably expected to realize, they at least brought him his full share of litigation, disappointment,

and severe trial; for, according to his own story, he was often in impecunious circumstances.

Of Francis Alton Calvert, inventor of the burr-cylinder, a few interesting facts, not hitherto published, may be related, the result of our interest in the man and his invention, which, be it said, stands second to none in its importance to the woollen trade. He was born near Cleckheaton, in Yorkshire, England, and enlisted into a regiment of horse. Stationed in Ireland he visited a ball one night, when, a riot breaking out, it was discovered that he was not on duty. His honors were stripped from him and future promotion denied him. He then deserted and came to the United States. After living at Lowell for some time he went to Graniteville, some nine miles from Lowell. Here he started a small shop to manufacture his newly invented metallic cylinders. Sometime after this a fire destroyed his shop, and he then built the mill, which still remains, but has been greatly enlarged. It was soon after the completion of this mill that he became associated in business with C. G. Sargent, whose son now carries on the business. After making some money he returned to England, having purchased his discharge, and then he went into partnership with Garnet, the inventor of the hard-waste or "Garnet" machine. Still retaining the partnership with Sargent, he returned to this country, and for years carried on a successful business. He finally returned to England, and there died. Some of his burr-pickers, rolls, etc., are still in operation.

THE END.

INDEX.